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Alaska Department of Fish and Game
Division of Commercial Fisheries
P.O. Box 3-2000
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Stock Assessment and Management of Pacific Herring in Prince William Sound, Alaska, 1988

by

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Samuel Sharr

and

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The Technical Fishery Report Series was established in 1987, replacing the Technical Data Report Series. The scope of this new series has been broadened to include reports that may contain data analysis, although data oriented reports lacking substantial analysis will continue to be included. The new series maintains an emphasis on timely reporting of recently gathered information, and this may sometimes require use of data subject to minor future adjustments. Reports published in this series are generally interim, annual, or iterative rather than final reports summarizing a completed study or project. They are technically oriented and intended for use primarily by fishery professionals and technically oriented fishing industry representatives. Publications in this series have received several editorial reviews and at least one *blind* peer review refereed by the division's editor and have been determined to be consistent with the division's publication policies and standards.

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ABSTRACT

An estimated 10,678.8 tonnes of Pacific herring (*Clupea harengus pallasii*) were harvested in Prince William Sound by five fisheries during 1987-88 management year. The 1987 food and bait fishery harvested 1,079.1 tonnes in 1987, and the four spring fisheries harvested 9,599.7 tonnes in 1988 with the purse seine sac roe fishery harvesting 7,163.0 tonnes, the gill net sac roe fishery harvesting 324.9 tonnes, the wild spawn-on-kelp fishery harvesting 701.1 tonnes, and the pound spawn-on-kelp fishery harvesting 1,410.7 tonnes. The estimated exploitation rate for the 1987-88 management year was 16.5% by weight and 15.7% by number. The estimated exploitation rate for the spring fisheries in 1988 was 15.1% by weight and 14.0% by number.

There were four major spawning concentrations of herring in Prince William Sound during 1988: (1) Montague Island area; (2) Naked Island area; (3) northeast shore area; and (4) north shore area. Based upon aerial surveys, 31,089.3 tonnes of herring spawned in these areas. This compared to 53,804.9 tonnes of herring spawning estimated from spawn deposition survey, which was 1.73 times larger than the aerial survey estimate. Using aerial surveys, herring were observed to have spawned on a total of 267.7 km of shoreline in the four areas.

The total spawning biomass of herring in Prince William Sound was estimated at 63,404.6 tonnes using the estimate from the spawn deposition survey and the harvests from the 1988 spring fisheries. The herring spawning in Prince William Sound had an estimated mean weight of 101 g. An estimated 54,506.0 tonnes of herring escaped the harvest. The herring that escaped the harvest had an estimated mean weight of 100 g.

The harvest, total spawning biomass, and escapement during 1987-88 were dominated by the 1984 year class of herring. Age-3 herring comprised 48.5% by weight and 51.1% by number of the harvest from the 1987 food and bait fishery. Age-4 herring comprised 61.2% by weight and 71.7% by number of the harvests from the 1988 sac roe and spawn-on-kelp fisheries; 76.2% by weight and 82.2% by number of the total spawning biomass; and 76.0% by weight and 82.0% by number of the escapement.

KEY WORDS: Pacific herring, *Clupea harengus pallasii*, Prince William Sound, spawning biomass estimation, aerial survey, spawn deposition survey, age-weight-length, sex, food and bait, sac roe, spawn-on-kelp, pound fishery

INTRODUCTION

Pacific herring (*Clupea harengus pallasii*) spawn throughout Prince William Sound each year from mid-April through early May. Even though the herring that spawn within Prince William Sound may be composed of several populations, the herring are managed as a single stock. This stock has been defined as those herring that spawn within the coastal waters between Point Whited and Cape Fairfield (Figure 1).

There are five commercial fisheries that harvest herring within Prince William Sound, Alaska, each year: (1) purse seine food and bait fishery; (2) purse seine sac roe fishery; (3) gill net sac roe fishery; (4) wild spawn-on-kelp fishery; and (5) pound spawn-on-kelp fishery. Since 1969 these fisheries have harvested an average of 6,516.0 tonnes of herring annually (Table 1). The purse seine sac roe fishery has harvested an average of 65.9% (4,685.2 tonnes) of the herring annually, followed by the wild spawn-on-kelp fishery with 28.3% (1,281.4 tonnes of equivalent herring), the food and bait fishery with 8.4% (646.1 tonnes), the pound spawn-on-kelp fishery with 5.6% (488.2 tonnes of equivalent herring), and the gill net sac roe fishery with 3.0% (239.0 tonnes).

The two spawn-on-kelp fisheries have annually harvested an average of 199.2 tonnes of spawn-on-kelp product since 1969 (Tables 2 and 3). The wild spawn-on-kelp fishery has accounted for most of the spawn-on-kelp harvest, averaging 160.1 tonnes of spawn-on-kelp product (Table 2). However, the pound spawn-on-kelp fishery, which developed from the wild spawn-on-kelp fishery in 1979 and has been increasing rapidly since 1985 (Randall et al. 1985), has had an average harvest of 39.1 tonnes of spawn-on-kelp product (Table 3).

In 1988 a detailed stock assessment program was conducted on the herring stock in Prince William Sound. The program consisted of: (1) monitoring the harvest from the fall food and bait fishery, the two sac roe fisheries, and the two spawn-on-kelp fisheries; (2) estimating the total spawning biomass of herring in Prince William Sound; and (3) estimating the age, weight, length, and sex composition of herring in the commercial harvest, total spawning biomass, and escapement. The commercial harvest of the five fisheries was monitored from harvest receipts (fish tickets) that were completed by processors when each fisherman delivers his or her harvest.

The spawning biomass of herring in Prince William Sound has been estimated each year since 1978 from aerial surveys, ranging from 8,371.5 tonnes in 1978 to 46,348.1 tonnes in 1981 (Brady 1987; Table 4). The biomass estimates from aerial surveys are estimates of the observable biomass. The aerial survey estimates are used to manage the fisheries in-season and evaluate the pre-season biomass projections. However, the accuracy or comparability of the aerial survey estimates are not believed to be great due to differences in observers, weather, water visibility, varying school depths, and varying spawning potential of the herring caused by differences in age structure (Randall et al. 1985; Brady 1987). Because of these differences, spawn deposition surveys were used in 1988 to estimate the spawning biomass (Biggs and Funk 1988). Spawn deposition surveys have been used extensively for estimating the spawning biomass of herring in British Columbia and Southeast Alaska (Haegle et al. 1981; Blankenbeckler and Larson 1987). The spawn deposition survey estimates are estimates of the spawning biomass after the completion of the spring fisheries.

Feasibility studies using spawn deposition survey techniques were conducted in Prince William Sound in 1983 and 1984 by Jackson and Randall (1983, 1984). They concluded that spawning biomass estimates from spawn deposition surveys were more precise than aerial survey estimates. From these spawn deposition studies, the spawning biomass of herring was estimated at 19,958.0 tonnes in 1983 and 72,311.8 tonnes in 1984 (Table 4).

The spawning success of herring has also been measured indirectly since 1978 by mapping the amount of shoreline where spawning was observed from aerial surveys. This measurement, kilometers of spawning, has ranged from 76.3 km in 1978 to 381.4 km in 1988 (Table 4).

Age, weight, length, and sex information has been collected each year since 1973 from the commercial harvest and test fishing conducted by the Alaska Department of Fish and Game (ADF&G; McCurdy 1986; Sandone et al. 1988a). This information has been used to estimate the age and sex composition, mean weight at age, and mean length at age, as well as and the contribution of each age class to the harvest of each commercial fishery, the total spawning biomass, and the escapement. This information has been used to update harvest strategies, monitor year class strengths, measure recruitment, and prepare a year-ahead forecast of abundance.

Objectives

The specific objectives of the 1988 Prince William Sound stock assessment program for herring were:

- 1) to estimate the age, sex, and size composition of the commercial harvest for each fishery, the total spawning biomass, and the escapement;
- 2) to determine the harvest of herring by the commercial fisheries;
- 3) to estimate the spawning biomass from both aerial surveys and spawn deposition surveys; and
- 4) to map the location, duration, and intensity of spawning along the shoreline.

Management of the Herring Fisheries in Prince William Sound

The herring stock in Prince William Sound during 1988 was managed on a sustained yield basis by following guideline harvest levels set forth by the Alaska Board of Fisheries in accordance with the Prince William Sound Herring Management Plan (Alaska Board of Fisheries 1986). After completion of the 1987 spring fisheries, the spawning biomass was projected for 1988 using the 1987 escapement (estimated from the spawn deposition and aerial survey programs) and adjusting for growth, mortality and recruitment. Guideline harvest levels provided for a sliding-scale harvest or exploitation rate ranging from 0% to 20% of the projected spawning biomass. Commercial fishing would not be allowed if the estimated spawning biomass was less than the threshold level of 7,620.0 tonnes. A maximum exploita-

tion rate of 20% was to be used if the estimated spawning biomass was 38,556.0 tonnes or greater. If the projected spawning biomass was between 7,620.0 and 38,556.0 tonnes, the level of harvest would be set between 0.0% and 20.0% based upon ADF&G's assessment of the status of the herring stock. For 1988 the estimated spawning biomass of herring was 39,908.9 tonnes (Sandone 1988b). The total harvest allocation for the commercial fisheries was 7,981.8 tonnes at a 20.0% exploitation rate.

The food and bait purse seine fishery is the first to occur in the management year, 1 July - 30 June. The food and bait fishery opens by regulation 1 September and may extend through 31 January. However, the fishery is closed by emergency order authority if the guideline harvest level is attained prior to 31 January. The guideline harvest level for the food and bait fishery in 1988 was a fixed allocation of 1,270.1 tonnes of herring. Legal gear for this fishery included purse seines, gill nets, and trawls (ADF&G 1988).

The pound spawn-on-kelp fishery occurs during April and May. Purse seines are used to collect mature herring that have not yet spawned. The captured herring are transferred from the purse seine into a net pen through the use of net doors. After the web of the door of the purse seine and the net pen have been laced together, the volume of water enclosed in the purse seine is reduced. This forces the herring to swim into the net pen after which the web door of the net pen is raised and closed. The net pen is then towed to the pound site where the herring are transferred into the pound in a similar fashion. However, before the transfer of herring into a pound, fronds of imported *Macrocystis* are suspended vertically from lines secured on the sides of the pounds. The kelp fronds serve as the spawning substrate for the adhesive herring eggs. The herring are released from the pounds after spawning activity is completed. The resulting spawn-on-kelp product is harvested. The pound webbing also receives herring spawn and must remain in the water until the herring embryos have hatched.

Participation in the pound fishery is governed by the Commercial Fisheries Entry Commission (CFEC). The pound fishery has a fixed guideline harvest allocation which is split equally among all permit holders each year. In 1988 the maximum number of permit holders was 122. The guideline harvest allocation for the pound fishery was 77.1 tonnes of spawn-on-kelp product (ADF&G 1988), which equated to 0.63 tonnes of spawn-on-kelp product per permit holder. The herring used in this fishery was estimated in 1988 assuming it took 12.5 tonnes of herring to produce 1.0 tonnes of spawn-on-kelp product in the pounds. Also, herring mortality was thought to be high due to stress, tissue damage, and scale loss which occurs during the confinement period. For management purposes, mortality of the pounded herring was assumed to be 100.0%. Therefore, it was estimated 963.8 tonnes of herring would be used by the pound fishery, or 7.9 tonnes of herring would be used by each permit holder.

The wild spawn-on-kelp fishery usually occurs in late April or early May. The spawn-on-kelp product is harvested by divers who cut the fronds about 4 in (10.2 cm) above the stem of the kelp. The location of the wild spawn-on-kelp fishery is determined from aerial surveys. The locations with the longest duration and intensity of spawning are the areas that will be opened for harvesting spawn-on-kelp product. The wild spawn-on-kelp fishery has a fixed guideline harvest allocation. In 1988 the guideline harvest allocation was 93.4 tonnes of wild spawn-on-kelp product (ADF&G 1988). The herring used in this fishery is estimated based upon the assumption that the mean roe recovery is

10.0% with 80.0% of the spawn-on-kelp product consisting of roe (eggs). Therefore, it was estimated 747.2 tonnes of herring would be used in the wild spawn-on-kelp fishery in 1988.

The purse seine and gill net sac roe fisheries usually occur during the later half of April. The timing of the sac roe fisheries are established to coincide with peak roe recovery in order to maximize fishery value. To prevent gear conflicts, the gill net sac roe fishery usually follows the closure of the purse seine fishery (Alaska Board of Fisheries 1986). The guideline harvest allocation for the two sac roe fisheries is the remainder of the overall harvest allocation after subtracting allocations to the food and bait fishery, pound spawn-on-kelp fishery, and wild spawn-on-kelp fishery. This allocation is split between the two sac roe fisheries with 94.5% allocated to the purse seine fishery and 5.5% allocated to the gill net fishery. The guideline harvest allocation for the two sac roe fisheries in 1988 was 5,000.7 tonnes of herring, with 4,725.7 tonnes (94.5%) allocated to the purse seine fishery and 275.0 tonnes (5.5%) to the gill net fishery. Participation in both sac roe fisheries also is governed by the CFEC. The maximum number of CFEC permits for the purse seine and gill net sac roe fisheries was 105 and 25 in 1988 (ADF&G 1988).

METHODS

Harvest Information and Estimates

Herring harvested by the food and bait, and the sac roe fisheries, and the spawn-on-kelp product harvested by the spawn-on-kelp fisheries were obtained from fish tickets. Estimates of the herring used in the wild and pound spawn-on-kelp fisheries were estimated from the weight of the harvested spawn-on-kelp product.

Age, Weight, Length, and Sex Statistics

Data Collection

Age, weight, length, and sex information were randomly collected from the 1987 fall commercial food and bait fishery, the 1988 commercial purse seine and gill net sac roe fisheries, the 1988 pound and wild spawn-on-kelp fisheries, and from ADF&G samples taken of major sightings of spawning herring throughout Prince William Sound. Samples were obtained during the food and bait, and sac roe fisheries from randomly selected fishing vessels throughout a management area. Ideally, during each fishing period, samples from the harvest of a minimum of five vessels were collected. Purse seine vessels waiting for a tender to pump their harvest were sampled by dipnetting fish from the seine net or from the tender. Samples were collected from the hold or deck of the gill net vessels. In the pound spawn-on-kelp fishery, samples were randomly collected prior to the herring being introduced into the pounds. From the major sightings of spawning herring, samples were collected by a ADF&G vessel and/or industry-volunteered vessels. Only gear types non-selective for size (purse and beach seines) were used to collect herring from the wild spawn-on-kelp fishery and samples from the major sightings of spawning biomass.

All samples collected were placed in polyethylene bags and clearly labeled with identification tags. The samples were picked up daily, or as weather permitted, by the aerial survey plane or a charter float plane. All samples were delivered to the lab at the Cordova ADF&G office, placed in fish totes, iced down, and logged in a sampling notebook.

In the laboratory, herring were randomly sampled from the fish totes. Ten herring were placed on a sampling tray at a time. Their weights were measured to the nearest 0.01 g using an electronic Dial-O-Gram type scale, their standard lengths (tip of snout to the end of the hypural plate) were measured to the nearest 1 mm using calipers, sex was determined from inspection of the gonads, and one readable scale from each fish was removed from the preferred area (between the left pectoral fin and the lateral line approximately three to four scales posterior to the fin origin).

Each scale was cleaned and checked for regeneration. If the scale was regenerated or unreadable, the process was repeated until one readable scale was found for each fish sampled. The individual scales from the ten fish were mounted on a labeled glass slide (25 x 75 x 1 mm) by dipping the readable scale into mucilage glue solution (1:10 solution of mucilage glue and water) and placing the scale on the glass slide. Labels for the glass slides included year, fishery, location, sample number, gear type, dates, and slide number. Each scale was pressed firmly against the slide with a paper towel after mounting to remove excess glue. After all ten scales had been mounted on a slide, a second glass slide was placed on top of the first and the two slides were taped together with cellophane tape. The completed scale mounts were stored in a slide box for subsequent age estimation and permanent storage.

Age of each herring sampled was estimated from the mounted scales by a committee of two or three persons. Scale images were projected on a microfiche reader (50 x) and each individual estimated the age independently. If the individuals estimated the age differently for a fish, then the differences were discussed and the age was estimated by mutual consensus.

Annulus formulation was assumed to take place in the spring of the year prior to spawning. Therefore, all herring sampled in the sac roe and spawn-on-kelp fisheries were assumed to have an annulus on the outer edge of each scale. The herring sampled in the fall food and bait fishery were not assumed to have an annulus on the outer edge of the scale unless one was clearly visible. When examined by age group, herring sampled from the food and bait fishery were from a year class one year older than the fish sampled in the 1988 sac roe and spawn-on-kelp fisheries. For example, in the 1988 sac roe fishery age-4 herring were from the 1984 year class, while age-4 herring from the 1987 food and bait fishery were from the 1983 year class. Correspondingly, a herring identified as age-3 in the fall food and bait fishery would become an age-4 herring in the sac roe and spawn-on-kelp fisheries the following spring.

A microcomputer was set up in the lab for data entry. Macro driven LOTUS 1-2-3 spreadsheets were used to enter all biological and sampling data as it was collected. The entered data was saved on diskettes. Lotus 1-2-3 macro functions were used to access the data and produce summary tables of the results.

Sample Sizes

Sampling for age, weight, length, and sex information was stratified by time, area, and fishery. The sample sizes for each time-area-fishery stratum for age, weight, length, and sex data was set at 600 fish at the beginning of the 1988 sac roe season and reduced to 560 fish in the middle of the season. The smaller sample size was adopted after a determination that it would meet precision and accuracy requirements, and still account for unreadable scales. The sample size was set to simultaneously estimate proportions by age when sampling from a multinomial population. The goal was to select the smallest sample size for a random sample from a multinomial population such that the probability was at least $1-\alpha$ (precision) that all the estimated proportions were simultaneously within 5% (accuracy = 0.05) of the true population age proportions. It was shown that a sample size of 600 fish would guarantee at least this level of precision and accuracy for any number of age classes and proportions (D.R. Bernard, Alaska Department of Fish and Game, Anchorage, personal communication) and allow for unreadable scales. However, during the middle of the season it was determined that less than 5% of the scales collected were unreadable. Therefore, the sample sizes were reduced to 560 fish for the remainder of the season.

It was of interest to identify temporal and spatial differences in the age, weight, length, and sex composition of herring in Prince William Sound. Samples collected from the same location on successive days or from adjacent locations on the same day were tested for differences in age compositions between samples with a chi-square test. Subsamples of approximately 300 herring were sampled from each strata. If the age compositions of the herring in the subsamples were not significantly different ($\alpha > 0.05$), then the subsamples were pooled into one sample of 600 fish. However, if the age composition were significantly different ($\alpha \geq 0.05$), then sampling would continue until 600 herring were collected from each stratum.

Data Analysis

The percent age composition (P_a), by sex, was estimated for each time-fishery-stratum as:

$$P_a = \frac{n_a}{n} 100, \quad (1)$$

where,

n_a = number of male or female herring in the sample that were age a , and
 n = total number of herring in the sample.

The percent sex composition (P_s) of herring for each time-fishery stratum was estimated as:

$$P_s = \frac{n_s}{n} 100, \quad (2)$$

where, n_s equals the number of male or female fish in a sample.

The mean weight at age (\bar{W}_a) for herring was estimated for each time-fishery stratum as:

$$\bar{W}_a = \frac{\sum W_a}{n_a}, \quad (3)$$

where, W_a equals the individual weight of the herring in the sample that were age a.

The variance for the sample weight at age ($\text{Var}[\bar{W}_a]$) was estimated as:

$$\text{Var}[\bar{W}_a] = \frac{\sum (W_a - \bar{W}_a)^2}{n_a - 1}. \quad (4)$$

The standard deviation of the sample weight at age was estimated by taking the square root of equation (4).

The mean length at age, variance, and standard deviation of the sample length-at-age measurements were calculated by substituting the individual length of each herring (L_a) for W_a in equations (2) and (3).

The contribution of each age class, by weight, to the harvest of each commercial fishery, escapement, and spawning biomass in each major spawning area was estimated as:

$$B_a = \frac{n_a \bar{W}_a}{\sum (n_a \bar{W}_a)} B, \quad (5)$$

where;

B_a = biomass of herring that was age a in the harvest of each commercial fishery, escapement, or spawning biomass in each major spawning area; and

B = total biomass of herring in the harvest of each commercial fishery, escapement, or spawning biomass in each major spawning area.

The contribution of each age class (N_a), by number, to the harvest of each commercial fishery, escapement, and spawning biomass for each major spawning area was estimated as:

$$N_a = \frac{B_a}{\bar{W}_a}. \quad (6)$$

The contribution of each age class to the herring harvested by the commercial food and bait and sac roe fisheries was estimated based upon the age composition and mean weight at age of herring sampled during the harvest. The contribution of each age class to herring used in the pound spawn-on-kelp fishery was estimated based upon the age composition and mean weight at age of herring sampled prior to their introduction into the pounds. The contribution of each age class to the wild spawn-on-kelp fishery was estimated based upon the age composition and mean weight at age of herring that were sampled by types non-selective for size (purse and beach seines) near the areas where the wild spawn-on-kelp fishery occurred.

If there was more than one opening and/or one of the commercial fisheries was opened in more than one area, the contribution of each age class to the harvest of the fishery was estimated separately for each opening and/or area based upon the age composition and mean weight at age of herring sampled during the separate openings and/or different areas. The estimated contribution of each age class (by weight and number) to the combined harvest of the fishery was estimated as by summing the estimated weight (tonne) and number of herring in each age class from the separate openings and/or areas. The mean weight at age for the combined harvest was then estimated by dividing the weight of each age class by the number of fish in each age class. Mean length-at-age was not estimated for the combined harvest.

The contribution of each age class to the total harvest of herring by all the commercial fisheries in Prince William Sound was estimated by summing the estimated weight (tonnes) and number of fish in each age class from all the commercial fisheries. The mean weight at age of the total harvest was estimated by dividing the weight of each age class by the number of fish in each age class. Mean length at age was not estimated for the total harvest.

The contribution of each age class to the escapement (by weight and number), mean weight at age, and mean length at age of the escapement was estimated for herring in each of the major spawning areas from (1) estimates of spawning biomass (spawn deposition surveys), (2) estimates of the use of herring in the wild spawn-on-kelp fishery, and (3) pooled samples of age, weight, and length data collected from herring captured by non size-selective gear types (purse and beach seines) within each major spawning area.

The contribution of each age class (by weight and number) to the total escapement was estimated by adding the estimated escapement from the major spawning areas to the estimated use in the wild spawn-on-kelp fishery. It should be remembered that herring used in the wild spawn-on-kelp fishery were included in both the total harvest and escapement estimates. The usage was included in the total harvest estimate because the spawn-on-kelp product (eggs) was harvested prior to the escapement estimate (spawn deposition survey). Including the usage in the harvest would account for the loss of the reproductive capacity of the herring due to egg removal. The usage was included in the total escapement estimate because the adult fish that deposited the eggs escaped the harvest and should return to spawn next year. The mean weight at age for the total escapement was then estimated by dividing the weight of each age class by the number of fish in each age class. Mean length at age was not estimated for the total escapement.

The contribution of each age class to the total spawning biomass was estimated by adding the total escapement, the harvest by the sac roe fisheries, and the use

The contribution of each age class to the total spawning biomass was estimated by adding the total escapement, the harvest by the sac roe fisheries, and the use by the pound spawn-on-kelp fishery. The herring used in the wild spawn-on-kelp fishery was only included in total spawning biomass estimate as part of the escapement and not in the harvest. The herring used in the wild spawn-on-kelp fishery were not actually harvested; including these fish would have meant adding them twice (once in the escapement and once in the harvest) to the total spawning biomass estimate. The mean weight at age for the total spawning biomass was then estimated by dividing the weight of each age class by the number of fish in each age class. Mean length at age was not estimated for the total spawning biomass.

The exploitation rate (by weight) was estimated for each age class of herring by dividing the weight of the total harvest by the weight of the total spawning biomass. The exploitation rate (by number) was also estimated for each age class by dividing the number of herring in the total harvest by the total number of herring spawning in Prince William Sound.

Aerial Surveys

Aerial Survey Methods

The first aerial survey was flown on 25 March 1988; however, adverse weather conditions precluded daily surveys through late March and into early April. When weather conditions improved, aerial surveys were conducted daily until the first part of May 1988. Aerial surveys were usually flown from a float equipped Cessna 185. Survey coverage of Prince William Sound normally included the mainland shoreline from St. Mathews Bay to Eaglek, the Naked Island group, Green Island and the northeastern portion of Montague Island (Figure 2). Areas of coverage were varied to focus on locations where spawning activity was concentrated. A typical survey covered up to 805 km of coastline and was normally terminated by the endurance limitations of the aircraft, which was approximately 5 h. Tide stage was not critical, but in general more herring were visible on a rising tide.

Biomass estimates were made on a surface area to biomass conversion. Schools of herring were classified into three different categories depending on the estimated surface diameter. A *small* school was about 15.25 m (50 ft) in diameter or approximately 9.1 tonnes of herring, a *medium* school was about 30.5 m (100 ft) in diameter or approximately 36.3 tonnes of herring, and a *large* school was about 61.0 m (200 ft) in diameter or approximately 145.1 tonnes of herring. Herring schools usually did not fall into one of the three size categories, and the observer converted these schools into the number of small, medium, and/or large schools. A tally counter was used to enumerate the number of schools by size and totals were recorded on standardized data forms.

To reduce variation in the observers' estimates because of water-surface distances, surveys were flown at a standard altitude of 457.2 m (1,500 ft). This occasionally was modified because of low clouds or other reasons. A sighting tube was used to calibrate the observer to standard surface distances at a specified survey altitude and viewing angle.

Spawning Biomass Estimation

The annual peak biomass was estimated from the aerial survey data as the sum of the peak biomass estimates recorded for all survey areas in Prince William Sound where herring were observed. This eliminated the possibility for double counting as only a single day's estimate was used for any given area. The only exception to this was if two separate waves of herring spawned in the same area but were clearly temporally distinct, then two peak counts from the same area were included in the annual peak biomass estimate.

Kilometers-of-Spawning

Herring spawn, as indicated by white milt in the water, was also documented on each survey. A set of detailed maps was carried by the observer. When spawn was observed, it was carefully charted to the nearest 0.16 km (0.1 mile) on the appropriate map. The annual kilometers-of-spawning was estimated from the aerial survey data as the sum of the kilometers of shoreline where milt was observed and charted. No adjustment was made for the intensity of observed spawn. A 1.0-km section of beach that receives spawn for only one day was given the same weight as 1.0-km section of beach that receives spawn for two or more days. It should be noted that the kilometers of spawning was an index of abundance for the herring that escaped the harvest by the sac roe fisheries.

Spawn Deposition Surveys

The objective of the spawn deposition surveys was to estimate the biomass of the spawning population of herring in Prince William Sound. Spawn deposition surveys were patterned after similar surveys in Southeast Alaska (Blankenbeckler and Larson 1982, 1985, 1987; Blankenbeckler 1987), and British Columbia (Schweigert et al. 1985). The spawning biomass was estimated in each major spawning area based upon an estimate of the total number of eggs deposited on the spawning grounds in each area, incorporating estimates of mean weight, sex ratio, and fecundity. Major spawning areas were identified and mapped during aerial surveys. The total spawning biomass was estimated by summing the estimates from all the major spawning areas. For a detailed description of the study design, data collection, data analyses, and results of the 1988 spawn deposition surveys conducted in Prince William Sound, see Biggs and Funk (1988).

Comparison of Spawning Biomass Estimates

A biomass ratio was estimated to compare the spawning biomass estimates from the aerial and spawn deposition surveys. The biomass ratio was estimated as the peak aerial survey estimate divided by the spawn deposition survey estimate. In comparing the spawning biomass estimates, it must be remembered that the peak aerial survey estimate is an estimate of the observable biomass and can be an estimate of the spawning biomass prior to the sac roe fisheries, whereas the spawn deposition survey estimates are estimates of the total spawning biomass after the completion of the sac roe and spawn-on-kelp fisheries. Therefore, the

harvest of the commercial fisheries should be added to the spawn deposition survey estimate when comparing the two estimates.

RESULTS

Harvest Estimates

1987 Food and Bait Fishery

The Prince William Sound food and bait fishery was opened by regulation on 1 September 1987 and closed by emergency order on 6 October 1987 (Table 5). The fishery was closed by ADF&G after a request from the processors for larger and firmer herring. It was believed the herring caught at a later date would be larger and firmer. The majority of herring were harvested near Knowles Head (Figure 2). A total of 467.2 tonnes of herring were harvested during this first opening (Table 5). The fishery was re-opened on 9 November 1987 and closed on 12 November 1987 when the harvest neared the guideline harvest level of 1,270.0 tonnes. The harvest during the second opening was 612.4 tonnes of herring. From the two openings, 1,079.1 tonnes of herring were harvested.

An estimated 58.8% by weight and 60.8% by number of the harvest was comprised of age-3 fish with the remainder mostly comprised of age-4 and -5 herring (Table 6). The herring from the first opening had a mean weight of 87 g and a mean length of 181 mm. The contribution of each age class and mean weight at age of herring in the harvest were determined from age-weight-length-sex (AWLS) samples (n=579) collected from the commercial harvest at Knowles Head on 2 September 1987 (Table 7). The sample was composed of 50.4% males and 49.6% females. There were only slight differences between the mean weight at age and mean length at age of males and females (nonstatistical comparison=NSC).

During the second opening, 40.7% by weight and 44.0% by number of the harvest was comprised of age-3 fish with the remainder almost equally comprised of age-2, -4 and -5 herring (Table 8). Herring from the second opening had a mean weight of 84 g and a mean length of 180 mm. The contribution of each age class and mean weight of herring in the harvest were determined from AWLS samples (n=546) collected from the commercial harvest at Knowles Head on 11 September 1987 (Table 9). The sampled fish were composed of 45.8% males and 54.2% females. There were only slight differences in the mean weight at age and mean length at age of males and females (NSC).

During the two openings, 48.5% by weight and 51.1% by number of the herring in the overall harvest were age-3 fish with the remainder mostly comprised of age-2, age-4, and age-5 herring (Table 10). Herring in the combined harvest had a mean weight of 85 g. The contribution of each age class, by weight and number, was determined by combining the estimated age composition of the two separate harvests (Tables 7 and 9).

Sac Roe Purse Seine Fishery

The purse seine sac roe fishery was opened in the north shore area (Figure 2) on 21 and 22 April 1988 for two 1-h fishing periods (Table 5). A total of 7,163.0 tonnes of herring were harvested by the 105 purse seine boats, with 3,117.8 tonnes harvested during the first opening and 4,045.2 tonnes harvested during the second opening. The mean roe recovery was estimated at 10.5%.

During the first opening, an estimated 59.7% by weight and 69.7% by number of the harvest was comprised of age-4 fish (1984 year class) with the remainder mostly split between age-5 through age-8 herring. The herring from the first opening had a mean weight of 112 g and a mean length of 199 mm. The contribution of each age class and mean weight of herring in the harvest were determined from AWLS samples collected from the commercial harvest at Cedar (n=291) and Granite (n=294) Bays, and Unakwik Inlet (n=293) in the north shore area of Prince William Sound on 21 April 1988 (Figure 2; Tables 12-14).

In Cedar Bay, the herring had a mean weight of 109 g and mean length of 197 mm (Table 12). Of the fish sampled, 55.0% were males and 45.0% were females. The sample was composed of 68.7% age-4 fish with the balance mostly comprised of age-5 through age-8 fish. The mean weight at age and mean length at age for the females was slightly larger than the males (NSC).

The herring in Granite Bay were smaller than the fish in Cedar Bay, having a mean weight of 99 g and mean length of 195 mm (Table 13). Of the fish sampled, 52.0% were males and 48.0% were females. In the sample, 81.0% of the herring were age-4. The mean weight at age and mean length at age for the females were again slightly larger than the males (NSC).

The herring in Unakwik Inlet were the largest of the three areas with a mean weight of 125 g and mean length of 206 mm (Table 14). Of the fish sampled, 56.0% were males and 44.0% were females. The sample was primarily composed of 59.4% age-4 herring. There were only slight differences between the mean weight at age and mean length at age of the males and females (NSC).

During the second opening, an estimated 61.1% by weight and 72.2% by number of the harvest was comprised of age-4 herring with the majority of the balance almost equally comprised of age-5 through age-8 herring (Table 15). Herring from this harvest had a mean weight of 110 g and a mean length of 202 mm. The contribution of each age class and mean weight of herring in the harvest were determined from AWLS samples (n=615) collected from the commercial purse seine harvest at the north shore area on 22 April 1988 (Table 16). Of the fish sampled, 50.7% were males and 49.3% were females. The females were larger than the males with the females having a mean weight of 115 g and mean length of 203 mm, compared to 106 g and 200 mm for the males.

During the two openings, 60.5% by weight and 71.1% by number of the herring in the harvest were age-4 fish with the remainder mainly comprised of age-5 through age-8 herring. The herring in the combined harvest had a mean weight of 111 g. The contribution of each age class, by weight and number, was determined by combining the estimated age composition of the harvest from the two openings (Tables 11 and 15).

Sac Roe Gill Net Fishery

The gill net sac roe fishery was opened in the North Shore area on 23 April 1988 for a 5.5 h fishing period (Figure 2; Table 5). A total of 324.9 tonnes of herring were harvested by 24 boats. The mean roe recovery was estimated at 10.0%.

During the opening, the majority of the harvest was equally split between age-7 (34.1% by weight, 35.4% by number) and age-8 (32.6% by weight, 31.9% by number) herring. The remainder of the harvest was comprised of herring ranging from age-4 through age-12. The herring from this harvest had a mean weight of 170 g and a mean length of 227 mm. The contribution of each age class and mean weight at age of herring in the harvest were determined from AWLS samples (n=565) collected from the commercial gill net harvest at the north shore area on 23 April 1988 (Table 19). Of the fish sampled, 54.0% were males and 46.0% were females. The females had larger mean weight at age than the males and a slightly larger mean length at age (NSC). The herring in this sample was a combined sample from the harvest by 2 1/8" and 2 1/4" mesh gill nets (Tables 20 and 21). As expected, the 2 1/8" mesh gill nets harvested smaller herring than the 2 1/4" mesh gill nets (NSC).

Fifty-five herring were sampled from the harvest of commercial vessels using 2 1/8" mesh gill nets (Table 20). The fish had a mean weight of 150 g and mean length of 219 mm. Of the fish sampled, 58.2% were males and 41.8% were females. The largest age class was age-8 herring which comprised 30.9% of the sample followed by age-5 and age-7 at 18.2%, age-4 at 12.7%, and age-6 at 9.1%. The females had larger mean weight at age than the males but were similar in mean length at age (NSC).

Three hundred forty-one herring were sampled from the harvest of commercial vessels using 2 1/4" mesh gill nets (Table 21). The fish had a mean weight of 171 g and mean length of 228 mm. Of the fish sampled, 50.7% were males and 49.3% were females. The majority of the sample was comprised of age-7 herring at 34.9% and age-8 herring at 34.0%. The females again had larger mean weight at age than the males and slightly larger mean length at age (NSC).

Wild Spawn-on-Kelp Fishery

The wild spawn-on-kelp fishery was opened for 4.0 h in Valdez Arm on 29 April 1988, and for 8.0 h in Fairmont and Wells Bays on 30 April 1988 (Figure 2) (Table 5). A total of 158 divers harvested 87.6 tonnes of wild spawn-on-kelp product of which 31.8 tonnes was harvested in Valdez Arm and 55.8 tonnes in Fairmont and Wells Bays. The herring biomass estimated to be used by this fishery was 701.1 tonnes, with 254.8 tonnes utilized in Valdez Arm, and 446.3 tonnes used in Fairmont and Wells Bays.

In the wild spawn-on-kelp fishery at Valdez Arm, the herring had a mean weight of 96 g and a mean length of 200 mm (Table 22). An estimated 59.9% by weight and 68.9% by number of the herring used in the fishery were age-4 with the majority of the remaining harvest split between age-7 and age-8 herring. The contribution of each age class and the mean weight were determined from AWLS samples collected from purse seine catches at Valdez Arm (n=470) on 24 April 1988 (Table 23). Of the fish sampled, 62.8% were males and 37.2% were females. The females had larger mean weight at age than the males and a slightly larger mean length at age (NSC).

In the wild spawn-on-kelp fishery at Fairmont Bay, the herring had an estimated mean weight of 113 g and a mean length of 202 mm (Table 24). An estimated 56.3% by weight and 67.2% by number of the herring used in the fishery were age-4 with the majority of the remaining harvest split between age-7 and age-8 herring. The contribution of each age class and the mean weight were determined from AWLS samples collected from commercial sac roe purse seine catches at Cedar Bay (n=291; Table 12), Granite Bay (n=294; Table 13), north shore area (n=615; Table 16); and from test fish purse seine catches at Fairmont Bay (n=548; Table 25) on 24 April 1988.

In Fairmont Bay, the herring had a mean weight of 125 g and mean length of 210 mm (Table 25). Of the fish sampled, 51.6% were males and 48.4% were females. The majority of the sample was comprised of age-4 herring (53.3%) with age-7 and age-8 each composing approximately 13.0%. The females had larger mean weight at age than the males and a slightly larger mean length at age (NSC).

In the combined wild spawn-on-kelp fishery, the herring had an estimated mean weight of 107 g (Table 26). An estimated 57.6% by weight and 67.9% by number of the herring used in the fishery were age-4 with the majority of the remaining herring split between age-7 and age-8 herring. The contribution of each age class, by weight and number, was determined by combining the estimated age composition of the harvest from the two openings (Tables 22 and 24).

Pound Spawn-on-Kelp Fishery

The pound spawn-on-kelp fishery was opened to purse seine herring for introduction into pounds in Valdez Arm from 12-23 April 1988 (Table 5). A total harvest of 112.9 tonnes of spawn-on-kelp was produced by the 122 permit holders. It was estimated that approximately 12.5 tons of herring were used to produce 1.0 tonnes of pound spawn-on-kelp product. From this, it was estimated 1,410.7 tonnes of herring were used in this fishery.

In the pound spawn-on-kelp fishery, an estimated 80.0% by weight and 84.8% by number of the herring used were age-4 (Table 27). The herring had a mean weight of 95 g and mean length of 191 mm. The contribution of each age class and the mean weight were determined from AWLS samples collected from herring used in the pound fishery at Galena (n=274) and Virgin (n=293) Bays prior to their introduction into the pounds (Tables 28 and 29).

In Galena Bay, an estimated 47.1% of the sampled fish were males and 52.9% females (Table 28). The herring in the sample were 82.0% age-4 fish, had a mean weight of 102 g, and a mean length of 195 mm. The females weighed more than the males, but had approximately the same mean length (NSC).

An estimated 50.2% of the sampled fish at Virgin Bay were males and 49.8% females (Table 29). The herring used were 87.4% age-4 fish, had a mean weight of 90 g, and a mean length of 188 mm. The females weighed slightly more than the males, but had approximately the same mean length (NSC).

Total Harvest

An estimated 10,678.8 tonnes of herring were harvested by the 1987 food and bait fishery, and the 1988 sac roe and spawn-on-kelp fisheries in Prince William Sound (Table 5). The ex-vessel value of all five fisheries was \$12,252,000 for the 1987-88 fishing season. The 1987 food and bait fishery harvested 1,079.1 tonnes of herring, which had an ex-vessel value of \$402,000. The 1988 sac roe fisheries harvested 7,487.9 tonnes of herring, while the 1988 spawn-on-kelp fisheries harvested 200.5 tonnes of spawn-on-kelp product. The harvest from the 1988 spring fisheries had an ex-vessel value of \$11,850,000. The herring in the combined harvest of the 1988 spring fisheries were composed of 61.2% by weight and 71.7% by number age-4 fish. The remainder of the herring were mostly split between age-5 and age-8 fish. The herring in the 1988 harvest had a mean weight of 109 g. The contribution of each age class, by weight and number, was determined by combining the estimated age composition of the harvest from the four spring fisheries (Tables 10, 17, 18, and 27). The mean weight of herring in the harvest was determined by dividing the weight of the harvest by the number of herring in the harvest of the two sac roe and two spawn-on-kelp fisheries.

Spawning Biomass Estimates

Montague Island Area

Based upon both aerial surveys and spawn deposition estimates, the largest biomass of spawning herring was near Montague Island (Table 31). In the Montague Island area 12,228.9 tonnes of herring were estimated from aerial surveys and 29,764.3 tonnes from the spawn deposition survey. The spawn deposition survey estimate was 2.43 times larger than the aerial survey estimate (Table 31). Herring spawned over an estimated 133.5 km of shoreline in the area (Tables 31 and 33). Based upon the aerial surveys, the majority of the herring spawned between 14 and 22 April 8 (Tables 32 and 33).

An estimated 84.1% by weight and 87.1% by number of the herring were age-4 (Table 34). The herring in this area had a mean weight of 96 g and a mean length of 195 mm. The contribution of each age class and mean weight was estimated based upon AWLS samples collected from test fish purse seine catches in Hanning Bay (n=568) at Montague Island on 17 April (Table 35). Of the herring samples, 43.8% were males and 56.2% were females. The female herring weighed more than the males and had a slightly longer mean length (NSC).

Herring were also sampled for AWLS information in the Montague (n=552) and Green Island (n=577) areas, but were not used to estimate age composition and mean weight at age of the spawning biomass in the area (Tables 36 and 37). The sample from the Montague Island area was not used because the sample was thought to be taken from the top of a school of herring and was not representative of the population present, nor was the sample from Green Island used because the sample was also considered not to be representative of the spawning stock in the area. No spawning was documented in the area the sample was taken in and the sample was collected outside the major spawning area.

At Montague Island, 70.1% of the herring were male and 29.9% were female (Table 36). The fish in the sample were composed of 59.8% age-4 and 30.8% age-3

fish. The herring sampled had a mean weight of 71 g and mean length of 176 mm. The female herring weighed slightly more than the males but had a similar mean length (NSC).

At Green Island, 53.4% of the herring were male and 46.6% were female (Table 37). The sample was composed of 86.0% age-4 herring. The herring had a mean weight of 93 g and a mean length 194 mm. The females in the sample had a larger mean weight and larger mean length than the males (NSC).

Naked Island Area

In the Naked Island area, the spawn deposition survey produced a biomass estimate of 12,505.5 tonnes that was 9.51 times larger than the aerial survey estimate of 1,315.4 tonnes (Table 31). Herring spawned on an estimated 30.1 km of shoreline in the area (Tables 31 and 32). Herring were observed in the area between 20 and 23 April 1988 (Tables 32 and 33).

Of the herring that spawned in the Naked Island area, 63.1% by weight and 72.8% by number were age-4 herring (Table 38). Herring sampled in this area had a mean weight of 107 g and mean length of 199 mm. The contribution of each age class and mean weight was estimated based upon an AWLS sample collected from test fish purse seine catches in the Naked Island area on 19 April 1988 (Table 39).

In McPherson Passage of the Naked Island area, 545 herring were sampled (Table 39). The sample was comprised of 49.2% males and 50.8% females. The females in the sample weighed more than the males by an average of 7 g and were slightly longer than the males (NSC).

Northeast Shore Area

In the Northeast Shore area, 6,688.9 tonnes were estimated from the spawn deposition survey which was 1.05 times larger the aerial survey biomass estimate of 6,386.6 tonnes (Table 31). The majority of the spawning biomass was observed during an aerial survey on 22 April 1988 (Table 32). Herring spawned on an estimated 166.8 km of shoreline (Tables 31 and 33).

Approximately 80.0% by weight and 84.7% by number of the herring in the Northeast Shore area were age-4 fish (Table 40). The herring in this area had a mean weight of 95 g and mean length of 191 mm. The contribution of each age class and mean weight was estimated based upon AWLS samples collected from herring utilized in the pound fishery at Galena and Virgin Bays (Tables 28 and 29). For a comparison of the samples collected, see the pound spawn-on-kelp fishery section in the results.

Test fish purse seine catches were also taken in Galena Bay on 8 and 9 April 1988 (Tables 41 and 42). On 8 April 1988, 195 herring were sampled (Table 41). The sampled herring were composed of 55.9% age-4 fish. Males composed 54.9% of the sample and females 45.1%. The herring had a mean weight of 120 g and mean length of 200 mm.

On 9 April 1988, 570 herring were sampled (Table 42). The sampled herring were composed of only 38.1% age-4 fish. The remainder of the herring sampled were

split between age-7 (19.3%) and age-8 (18.4%) fish. Males composed 48.8% of the sample and females 51.2%. The herring had a mean weight of 133 g and mean length of 206 mm.

North Shore Area

In the North Shore area, 4,846.2 tonnes were estimated from the spawn deposition surveys which were 0.43 times smaller than the 11,158.4 tonnes estimated during the aerial surveys (Table 31). Herring spawned on an estimated 24.8 km of shoreline in the area (Tables 31 and 33). The majority of the spawning herring were observed in the area between 20 and 23 April 1988 (Tables 32 and 33).

Based upon the spawn deposition survey, 56.3% (by weight) and 67.2% (by number) were age-4 herring (Table 43). The herring in this area had a mean weight of 113 g and mean length of 202 mm. The contribution of each age class and the mean weight were determined from AWL samples collected from commercial purse seine catches at Cedar Bay (Table 12), Granite Bay (Table 13), North Shore area (Table 16); and from test fish purse seine catches at Fairmont Bay (Table 25). Test fish purse seine catches were also conducted in Wells and Olsen Bays but were not used to apportion the biomass because they were collected early and not considered representative of the biomass in the area (Tables 44 and 45).

In Wells Bay, herring were composed of 83.2% age-4 fish (n=560) (Table 44). Males composed 51.4% of the sample and females 48.6%. The herring had a mean weight of 93 g and mean length of 186 mm.

At Olsen Bay, herring composed only 52.4% age-4 fish (n=580) (Table 45). The remainder of the herring sampled were split between age-3 (10.5%), age-5 (10.2%), and age-7 (14.0%) fish. Males composed 71.0% of the sample and females 29.0%. The herring had a mean weight of 88 g and mean length of 189 mm.

All Areas Combined

Based upon aerial surveys, and estimated 31,089.3 tonnes of herring spawned in the major spawning areas within Prince William Sound in 1988. This compared to a estimate of 53,804.9 tonnes of spawning herring in Prince William Sound based upon the spawn deposition survey (Table 31). The spawn deposition survey estimate was 1.73 times larger than the aerial survey estimate. Herring were observed to have spawned on a total of 381.4 km of shoreline in the four areas (Tables 31 and 33). The majority of the herring were observed in Prince William Sound between 19 and 23 April 1988 (Tables 32 and 33). Spawning herring were composed of age-4 fish (76.2% by weight and 82.2% by number). The herring population overall had a mean weight of 100 g. The estimated spawning biomass, weight and number, was estimated by adding the spawning biomass from the four areas (Tables 34, 38, 40, and 43).

Total Escapement, Spawning Biomass, Exploitation Rate

An estimated 54,506.0 tonnes of herring escaped the harvest in Prince William Sound in 1988 (Table 47). Approximately 76.0% by weight and 82.0% by number were

age-4 herring. The herring that escaped harvest had a mean weight of 100 g. The escapement was the sum of the estimated spawning biomass from the spawn deposition surveys (Table 46) and the estimated use by the wild spawn-on-kelp fishery (Table 26).

The total spawning biomass of herring in Prince William Sound was estimated at 63,404.6 tonnes (Table 48). The majority, 73.9% by weight and 80.7% by number, were age-4 herring. The estimated mean weight for the herring population was 101 g. The total spawning biomass was the sum of the estimated spawning biomass from the spawn deposition surveys (Table 46) and the total harvest and use by the 1988 sac roe and spawn-on-kelp fisheries (Table 30).

The exploitation rate for herring in Prince William Sound was 15.1% by weight and 14.0% by number (Tables 48 and 50). Of the 63,404.6 tonnes of herring estimated to have spawned in Prince William Sound, an estimated 9,599.7 tonnes or 15.1% of the herring were harvested or used by the two sac roe fisheries and two spawn-on-kelp fisheries.

DISCUSSION

The total harvest of 10,678.8 tonnes of herring by the five commercial fisheries during 1987-1988 exceeded the harvest allocation of 7,981.8 tonnes by 2,697.0 tonnes or 33.8%. All the commercial fisheries exceeded the guideline harvest level except the 1987 food and bait fishery and the 1988 wild spawn-on-kelp fishery. The 1987 food and bait harvest of 1,079.1 tonnes was less than the allocation of 1,270.1 tonnes by 191.0 tonnes. The wild spawn-on-kelp fishery harvested 87.6 tonnes of spawn-on-kelp product which was less than harvest allocation of 93.4 tonnes by 5.8 tonnes. The largest difference in the harvest allocation was by the purse seine sac roe fishery. The purse seine sac roe fishery harvested 7,163.0 tonnes. This was over the harvest allocation of 4,725.6 tonnes by 2,437.4 tonnes or 51.5%. The gill net sac roe fishery harvested 324.9 tonnes which exceeded the harvest allocation of 275.0 tonnes by 49.9 tonnes or 18.1%. Finally, the pound spawn-on-kelp fishery harvested 112.9 tonnes of spawn-on-kelp product which exceeded the harvest of 77.1 tonnes by 35.8 tonnes or 46.4%.

There were four major spawning concentrations of herring in Prince William Sound; (1) Montague Island area, (2) Naked Island area, (3) Northeast Shore area, and the (4) North Shore area (Figure 2). Both aerial surveys and spawn deposition surveys were conducted to estimate the spawning biomass in the four areas. The differences between spawning biomass estimates from aerial surveys and spawn deposition surveys varied greatly within the four major spawning areas. However, the estimates were similar in areas where aerial surveys were flown on a regular basis. In the Montague and Naked Island areas, aerial surveys were not flown on a regular basis. The Montague Island area estimates varied from 12,228.9 tonnes (aerial surveys) to 29,764.3 tonnes (spawn deposition survey). It is believed a large portion of the spawning biomass in this area was not included in the aerial survey. Extensive spawn was documented on the north end of Montague Island. However, very little spawning biomass was observed in the area during aerial surveys. The estimates in the Naked Island area varied greatly from 1,315.4 tonnes (aerial surveys) to 12,505.5 tonnes (spawn deposition surveys). In the northeast and north shore areas, aerial surveys were conducted regularly. The

aerial survey estimate (6,386.6 tonnes) was very similar to the spawn deposition survey estimate (6,688.9 tonnes) in the northeast shore area. However, before comparing the estimates in this area, the herring used by the spawn-on-kelp fisheries in the area needed to be added to the spawn deposition survey estimate. The adjusted difference was 6,386.6 tonnes (aerial survey estimate) versus 8,354.4 tonnes [6,688.9 tonnes (spawn deposition survey) + 254.3 tonnes (wild spawn-on-kelp fishery) + 1,410.7 tonnes (pound spawn-on-kelp fishery)]. This adjusted difference in the northeast shore area was still not very large. In the north shore area, the aerial survey estimate was 11,158.4 tonnes compared to 4,846.2 tonnes from the spawn deposition survey. However, the discrepancy was explained when the harvest by the commercial fisheries in the area were added to the spawn deposition estimate. The adjusted estimate was 12,780.4 tonnes [4,846.2 tonnes + 7,163 (sac roe fisheries) + 446.3 tonnes (wild spawn-on-kelp fishery)] compared to 11,158.4 tonnes.

The exploitation rate for the 1988 spring sac roe fisheries was estimated at 15.1% by weight and 14.0% by number. The total exploitation rate (by weight) for the 1987-88 season was also estimated by adding the harvest of the food and bait fishery to both the total spawning biomass and the harvest and use of the 1988 sac roe and spawn-on-kelp fisheries. Dividing the total harvest (10,678.8 tonnes) by the total biomass (64,483.7 tonnes) produced an estimated exploitation rate of 16.5% for the 1987-88 fishing season, which was less than the guideline allocation of 20%.

As was expected, the harvest and utilization by the five commercial fisheries, escapement, and total spawning biomass of herring in Prince William Sound during 1988 was dominated by the 1984 year class. Based upon weight and number of herring, the 1984 year class composed anywhere from 60.0% to 85% of the total spawning biomass, escapement, and harvest of the commercial fisheries.

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Table 1. Harvest of Pacific herring by the commercial bait and food and sac roe fisheries, and the estimated use of Pacific herring in the wild and pound spawn-on-kelp fisheries in Prince William Sound, Alaska, 1969-88.

Harvest Year ^e	Pacific Herring Harvest ^a						Pacific Herring Utilization ^a				Estimated and (tonnes)
	Bait and Food Fishery ^b		Sac Roe Fisheries				Total				
			Purse Seine		Gill Net		Spawn-on-Kelp Fisheries		Harvest		
Wild Kelp ^d											
Utilization											
(tonnes)	%	(tonnes)	%	(tonnes)	%	(tonnes)	%	(tonnes)	%		
1969			322.7	94.4				19.2	5.6	341.9	
1970	9.1	1.3						690.5	98.7	699.6	
1971	18.1	0.5	834.0	22.9				2,791.6	76.6	3,643.7	
1972	4.4	0.1	1,608.1	42.5				2,174.7	57.4	3,787.2	
1973	7.7	0.1	6,336.1	85.0				1,111.5	14.9	7,455.3	
1974			5,777.1	74.2	3.4	0.0		2,003.4	25.7	7,784.0	
1975			5,517.1	62.4				3,327.9	37.6	8,845.0	
1976			2,344.6	57.1				1,759.6	42.9	4,104.2	
1977			2,071.0	57.8	1.5	0.0		1,513.2	42.2	3,585.7	
1978	229.2	11.4	1,206.2	60.2	56.0	2.8		511.3	25.5	2,002.7	
1979	1,170.2	17.6	3,754.5	56.5				1,717.1	25.9	6,641.8	
1980	595.1	7.0	5,482.3	64.1	240.0	2.8	15.1	0.2	2,221.9	26.0	8,554.3
1981	1,285.0	8.8	12,492.5	85.9	212.8	1.5	109.5	0.8	444.2	3.1	14,544.0
1982	1,145.4	12.2	6,484.8	69.0	357.3	3.8	289.6	3.1	1,123.5	12.0	9,400.6
1983	801.2	16.8	2,471.4	51.7	95.6	2.0	314.5	6.6	1,100.2	23.0	4,783.0
1984	248.2	4.0	5,295.2	86.2	311.1	5.1	285.9	4.7			6,140.3
1985	926.9	11.1	6,423.1	77.1	374.9	4.5	455.5	5.5	149.9	1.8	8,330.3
1986	1,014.3	8.8	8,915.9	77.5	407.0	3.5	818.7	7.1	345.5	3.0	11,501.4
1987	1,157.8	15.4	4,519.8	60.3	483.8	6.5	694.0	9.3	640.1	8.5	7,495.4
1988	1,079.1	10.1	7,163.0	67.1	324.9	3.0	1,410.7	13.2	701.1	6.6	10,678.8
n	15	15	19	19	12	12	9	9	19	19	20
Mean	646.1	8.4	4,685.2	65.9	239.0	3.0	488.2	5.6	1,281.4	28.3	6,516.0
SE	130.5	1.6	705.9	3.9	47.7	0.6	143.4	1.4	212.0	6.0	822.1
Min	4.4	0.1	322.7	22.9	1.5	0.0	15.1	0.2	19.2	1.8	341.9
Max	1,285.0	17.6	12,492.5	94.4	483.8	6.5	1,410.7	13.2	3,327.9	98.7	14,544.0

^a 1.0 tonnes = 1.10231 tons.

^b Gear type used included purse seine, pair trawl, mid-water trawl, and otter trawl. However, since 1982 purse seines have been used exclusively.

^c The biomass used by the pound spawn-on-kelp fishery was estimated based on the assumption that 12.5 tonnes of herring were used to produce 1.0 tonnes of spawn-on-kelp product.

^d The biomass used by the wild spawn-on-kelp fishery was estimated based on a mean roe recovery of 10%, with 80% of the spawn-on-kelp harvest consisting of roe (eggs).

^e The harvest year for the fall food and bait fishery actually occurred in the year prior to the harvest year listed in the table. As an example, the food and bait harvest in the 1988 harvest year was actually the harvest for the 1987 fall food and bait fishery. It was recorded this way because the management year for herring was defined to occur from 1 July through 31 June of the following year.

Table 2. Summary of Pacific herring wild spawn-on-kelp harvest in Prince William Sound, 1969-88.

Year	Date of Fishery	Hours	Effort (Divers)	Spawn-on-Kelp Harvest		Pacific Herring Utilized (tonnes) ^b
				kg	tonnes ^a	
1969	18 May-31 May		3	2,404	2.4	19.2
1970	19 April- 6 Jun		29	86,319	86.3	690.5
1971	18 April-15 May		34	348,949	348.9	2,791.6
1972	30 April-20 May		397	271,838	271.8	2,174.7
1973	23 April-26 May		176	138,936	138.9	1,111.5
1974	22 April- 4 May		166	250,429	250.4	2,003.4
1975	25 April-10 May		437	415,990	416.0	3,327.9
1976	21 April- ?		357	219,947	219.9	1,759.6
1977	27 April-31 December		164	189,148	189.1	1,513.2
1978	20-30 April		66	63,911	63.9	511.3
1979	25 April- 3 May		198	214,640	214.6	1,717.1
1980	23-30 April	10	469	277,735	277.7	2,221.9
1981	25 April	12	214	55,520	55.5	444.2
1982	5 May- 8 May	73	151	140,432	140.4	1,123.5
1983	27 April	12	186	137,529	137.5	1,100.2
1984	Season Closed	20	225			
1985	6 May- 8 May	20	95	18,733	18.7	149.9
1986	30 April- 3 May	86	29	43,182	43.2	345.5
1987	15-17 April	44	60	80,014	80.0	640.1
1988	29-30 April	12	158	87,634	87.6	701.1
<hr/>						
n		9	20	19	19	19.0
Mean		32	181	160,173	160.1	1,281.4
SE		10	31	26,501	26.5	212.0
Min		10	3	2,404	2.4	19.2
Max		86	469	415,990	416.0	3,327.9

^a 1.0 tonnes = 1.10231 tons.

^b The estimate of herring used by the wild spawn-on-kelp fishery was based on a mean roe recovery of 10%, with 80% of the spawn-on-kelp harvest consisting of roe (eggs).

Table 3. Summary of Pacific herring pound spawn-on-kelp harvest in Prince William Sound, Alaska, 1979-88.

Year	Date of Fishery ^a	Permits Issued ^b	Pounds Built ^c	Producing Pounds ^d	Spawn-on-Kelp Harvest ^e						Herring (tonnes) ^f
					Ribbon		Macrocystis		Pacific Total Utilized		
					kg	tonnes	kg	tonnes	kg	tonnes	
1979		2	0								
1980	14 April	14	4	2	803	0.8	399	0.4	1,202	1.2	15.0
1981	14 April	18	18	7	7,810	7.8	953	1.0	8,762	8.8	109.5
1982	29 April-10 May	25	20	18	22,754	22.8	408	0.4	23,163	23.2	289.5
1983	30 April- 4 May	47	38	26	16,041	16.0	9,117	9.1	25,158	25.2	314.5
1984	24 April- 8 May	65	45	37	5,824	5.8	17,042	17.0	22,866	22.9	285.8
1985	25 April- 7 May	81	59	50	10,976	11.0	25,461	25.5	36,437	36.4	455.5
1986	21-28 April	104	82	81	0	0.0	65,499	65.5	65,499	65.5	818.7
1987	10-21 April	111	111	108	0	0.0	55,520	55.5	55,520	55.5	694.0
1988	12-23 April	122	122	119	0	0.0	112,854	112.9	112,854	112.9	1,410.7
n		10	10	9	9	9	9	9	9	9	9
Mean		58.9	49.9	49.8	7,134	7.1	31,917	31.9	39,051	39.1	488.1
SE		13.9	13.6	14.4	2,721	2.7	12,890	12.9	11,476	11.5	143.4
Min		2	0	2	0	0.0	399	0.4	1,202	1.2	15.0
Max		122	122	119	22,754	22.8	112,854	112.9	112,854	112.9	1,410.7

^a Dates the fishery was opened to the seining of herring for placement into pounds.

^b Permits issued to registered applicants prior to the 1 March deadline.

^c Number of individual pounds constructed by the 1 April deadline, and consequently the number of individuals receiving an equal allocation of the guideline harvest.

^d Number of pounds that were successful in producing spawn-on-kelp product. Due to the group cooperation in this fishery production is frequently reported for a few individuals whose pounds did not produce spawn-on-kelp product.

^e Production figures represent processed weights as reported on harvest receipts (fish tickets).

^f The estimate of herring used in the pound spawn-on-kelp fishery was estimated based on the assumption that 12.5 tonnes of Pacific herring were used to produce 1.0 tonnes of spawn-on-kelp product.

Table 4. Spawning biomass estimates and indices for Pacific herring in Prince William Sound, Alaska, 1978-88.

Year	Spawning Biomass Estimates ^a			Biomass of Herring per Kilometer (tonnes) ^a		
	Peak Aerial Survey (tonnes)	Spawn Deposition (tonnes)	Kilometers of Spawning ^b	Aerial Survey Estimate	Spawn Deposition Estimate	Biomass Ratio ^c
1978	8,371.5		76.3	109.7		
1979	28,695.2		108.0	265.7		
1980	45,217.8		85.8	527.0		
1981	46,348.1		160.5	288.8		
1982	31,625.4		95.2	332.2		
1983	30,665.6	19,958.0	80.0	383.3	249.5	0.65
1984	41,417.6	72,311.8	105.9	391.1	682.8	1.75
1985	23,733.8		134.0	177.1		
1986	13,743.9		126.6	108.6		
1987	21,854.1		117.2	186.2		
1988	31,089.3	53,804.9	381.4	81.5	141.1	1.73
n	11	3	11	11	3	3
Mean	29,342.0	48,691.6	133.7	259.2	357.8	1.38
SE	3,653.3	15,328.0	25.9	42.6	165.5	0.36
Min	8,371.5	19,958.0	76.3	81.5	141.1	0.65
Max	46,348.1	72,311.8	381.4	527.0	682.8	1.75

^a 1.0 tonnes = 1.10231 tons.

^b 1.0 kilometers = 0.6211 miles.

^c Biomass ratio was the spawn deposition estimate divided by the peak aerial survey estimate.

Table 5. Season, location, effort, and harvest, by gear type, for the commercial Pacific herring fisheries in Prince William Sound, Alaska, 1988.

Fishery	Fishing Information				Harvest (Tonne)	
	Area	Date	Duration	Effort	Spawn-on-Kelp	Pacific Herring
1987 Food and Bait	Knowles Head	1 September-6 October 1987		7 boats		467.2
	Knowles Head	9-12 November 1987		7 boats		611.9
Total 1987 Food and Bait Harvest		1 September-12 November 1987		7 boats		1,079.1
<u>1988 Sac Roe and Spawn-on-Kelp Fisheries</u>						
Purse Seine Sac Roe	North Shore	21 April 1988	1.0 hrs	86 boats		3,117.8
	North Shore	22 April 1988	1.0 hrs	95 boats		4,045.2
	Total	21-22 April 1988	2.0 hrs	105 boats		7,163.0
Gill Net Sac Roe	North Shore	23 April 1988	5.5 hrs	24 boats		324.9
	Total	23 April 1988	5.5 hrs	24 boats		324.9
Wild Spawn-on-Kelp ^a	Valdez Arm	29 April 1988	4.0 hrs	113 divers	31.8 ^b	254.8 ^c
	Fairmont/Wells Bay	30 April 1988	8.0 hrs	121 divers	55.8 ^b	446.3 ^c
	Total	29-30 April 1988	12.0 hrs	158 divers	87.6 ^b	701.1 ^c
Pound Spawn-on-Kelp ^d	Galena Bay	12-23 April 1988		122 permits	112.9	1,410.7 ^e
	Tatitlek					
	Total	12-23 April 1988		122 permits	112.9	1,410.7 ^e
Total 1988 Harvest and Utilization					200.5	9,599.7
1987 - 1988 Harvest and Utilization					200.5	10,678.8

^a The harvest by divers of naturally occurring herring roe on native kelp species in Prince William Sound.

^b The harvest consisted of approximately 64% ribbon kelp, 24% sieve kelp, and 12% hair kelp.

^c The equivalent harvest of herring (due to the removal of the reproductive capacity from the population) was estimated based on a mean roe recovery of 10%, with 80% of the spawn-on-kelp harvest weight consisting of roe (eggs).

^d The harvest of herring spawn-on-kelp produced in net pens or pounds.

^e The equivalent harvest of herring (due to stress mortality and the removal of the reproductive capacity of the population) was estimated based on 12.5 tonnes of herring utilized to produce 1.0 tonne of spawn-on-kelp product.

Table 6. Estimates of the contributions of each age and year class to the Pacific herring harvested by the commercial purse seine food and bait fishery in Prince William Sound, Alaska, 1 September - 6 October 1987.

Year Class	Age Class	Number Sampled	Mean Weight (g)	Mean Standard Length (mm)	Harvest by Age Class			
					Weight (tonnes)	Percent by Weight	Number of Fish (x 1,000)	Percent by Number
1985	2	46	68	169	29.0	6.2	427.1	7.9
1984	3	352	84	179	274.5	58.8	3,267.9	60.8
1983	4	101	94	185	88.1	18.9	937.7	17.4
1982	5	62	98	189	56.4	12.1	575.6	10.7
1981	6	11	112	200	11.4	2.4	102.1	1.9
1980	7	7	118	198	7.7	1.6	65.0	1.2
Total		579	87	181	467.2	100.0	5,375.4	100.0

Table 7. Age and sex composition, mean weight-at-age, and mean length-at-age of Pacific herring sampled from the harvest of the commercial purse seine food and bait fishery at Knowles Head, Prince William Sound, Alaska, 2 September 1987.

Age	Age and Sex Composition						Weight (g)						Standard Length (mm)					
	Male		Female		Combined		Male		Female		Combined		Male		Female		Combined	
	n	%	n	%	n	%	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
2	22	3.8	24	4.1	46	7.9	67	9	69	9	68	9	169	8	170	7	169	7
3	192	33.2	160	27.6	352	60.8	85	15	83	12	84	13	179	9	179	8	179	8
4	48	8.3	53	9.2	101	17.4	97	17	92	13	94	15	185	9	185	8	185	8
5	23	4.0	39	6.7	62	10.7	97	13	98	14	98	14	189	8	189	8	189	8
6	3	0.5	8	1.4	11	1.9	106	17	114	24	112	23	197	10	202	12	200	12
7	4	0.7	3	0.5	7	1.2	119	15	116	23	118	19	197	7	199	10	198	8
Total	292	50.4	287	49.6	579	100.0	87	17	87	16	87	16	181	10	181	10	181	10
Unaged	14	66.7	7	33.3	21	100.0	83	19	89	22	85	20	178	11	183	15	180	13

Table 8. Estimates of the contributions of each age and year class to the Pacific herring harvested by the commercial purse seine food and bait fishery in Prince William Sound, Alaska, 9-12 November 1987.

Year Class	Age Class	Number Sampled	Mean Weight (g)	Mean Standard Length (mm)	Harvest by Age Class			
					Weight (tonnes)	Percent by Weight	Number of Fish (x 1,000)	Percent by Number
1985	2	99	65	167	85.6	14.0	1,317.3	18.1
1984	3	240	78	176	249.1	40.7	3,193.4	43.9
1983	4	93	93	187	115.1	18.8	1,237.5	17.0
1982	5	82	104	193	113.5	18.5	1,091.1	15.0
1981	6	26	114	200	39.4	6.4	346.0	4.8
1980	7	5	112	199	7.5	1.2	66.5	0.9
1979	8	1	131	207	1.7	0.3	13.3	0.2
Total		546	84	180	611.9	100.0	7,265.0	100.0

Table 9. Age and sex composition, mean weight-at-age, and mean length-at-age of Pacific herring sampled from the harvest of commercial purse seine food and bait fishery at Knowles Head, Prince William Sound, Alaska, 11 November 1987.

Age	Age and Sex Composition						Weight (g)						Standard Length (mm)					
	Male		Female		Combined		Male		Female		Combined		Male		Female		Combined	
	n	%	n	%	n	%	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
2	50	9.1	49	9.0	99	18.1	66	7	64	7	65	7	168	6	166	6	167	6
3	122	22.3	118	21.6	240	43.9	78	12	78	11	78	12	176	9	177	8	176	8
4	40	7.3	53	9.7	93	17.0	93	15	93	12	93	13	185	10	188	8	187	9
5	27	4.9	55	10.1	82	15.0	100	17	106	16	104	17	190	9	195	9	193	9
6	10	1.8	16	2.9	26	4.8	118	15	111	21	114	19	199	6	200	11	200	9
7	1	0.2	4	0.7	5	0.9	114	0	111	14	112	12	190	0	201	10	199	10
8	0	0.0	1	0.2	1	0.2			131	0	131	0			207	0	207	0
Total	250	45.8	296	54.2	546	100.0	82	18	86	20	84	19	178	12	182	14	180	13
Unaged	31	58.5	22	41.5	53	100.0	84	21	92	21	87	21	180	14	187	15	183	15

Table 10. Estimates of the contributions of each age and year class to the Pacific herring harvested by the commercial purse seine food and bait fishery in Prince William Sound, Alaska, 1 September - 12 November 1987.

Year Class	Age Class	Mean Weight (g)	Harvest by Age Class			
			Weight (tonnes)	Percent by Weight	Number of Fish (x 1,000)	Percent by Number
1985	2	66	114.7	10.6	1,744.3	13.8
1984	3	81	523.6	48.5	6,461.3	51.1
1983	4	93	203.2	18.8	2,175.1	17.2
1982	5	102	169.9	15.7	1,666.7	13.2
1981	6	114	50.9	4.7	448.1	3.5
1980	7	115	15.1	1.4	131.5	1.0
1979	8	131	1.7	0.2	13.3	0.1
Total		85	1,079.1	100.0	12,640.4	100.0

Table 11. Estimates of the contributions of each age and year class to the Pacific herring harvested by the commercial purse seine sac roe fishery in Prince William Sound, Alaska, 21 April 1988.

Year Class	Age Class	Number Sampled	Mean Weight (g)	Mean Standard Length (mm)	Harvest by Age Class			
					Weight (tonnes)	Percent by Weight	Number of Fish (x 1,000)	Percent by Number
1985	3	10	66	171	20.9	0.7	317.0	1.1
1984	4	612	96	192	1,862.6	59.7	19,402.3	69.7
1983	5	67	122	206	259.1	8.3	2,124.1	7.6
1982	6	35	151	221	167.6	5.4	1,109.6	4.0
1981	7	79	157	222	393.2	12.6	2,504.5	9.0
1980	8	56	168	226	298.3	9.6	1,775.4	6.4
1979	9	5	182	232	28.8	0.9	158.5	0.6
1978	10	2	203	248	12.9	0.4	63.4	0.2
1977	11	6	186	237	35.4	1.1	190.2	0.7
1976	12	6	205	242	39.0	1.3	190.2	0.7
Total		878	112	199	3,117.8	100.0	27,835.4	100.0

Table 12. Age and sex composition, mean weight-at-age, and mean length-at-age for Pacific herring sampled from the harvest of the commercial purse seine sac roe fishery at Cedar Bay, North Shore area, Prince William Sound, Alaska, 21 April 1988.

Age	Age and Sex Composition						Weight (g)						Standard Length (mm)					
	Male		Female		Combined		Male		Female		Combined		Male		Female		Combined	
	n	%	n	%	n	%	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
3	4	1.4	1	0.3	5	1.7	66	7	76		68	8	169	8	176		170	8
4	109	37.5	91	31.3	200	68.7	95	12	100	15	97	14	191	7	192	9	191	8
5	14	4.8	13	4.5	27	9.3	120	21	122	12	121	17	206	11	203	6	205	9
6	8	2.7	5	1.7	13	4.5	140	14	150	10	144	13	216	6	221	4	218	6
7	14	4.8	12	4.1	26	8.9	149	22	167	11	157	20	216	11	225	4	220	10
8	6	2.1	9	3.1	15	5.2	157	7	177	21	169	19	222	6	227	6	225	7
9	2	0.7	0	0.0	2	0.7	186	13			186	13	229	3			229	3
10	1	0.3	0	0.0	1	0.3	215				215		252				252	
11	1	0.3	0	0.0	1	0.3	213				213		231				231	
12	1	0.3	0	0.0	1	0.3	212				212		241				241	
Total	160	55.0	131	45.0	291	100.0	106	28	113	30	109	29	196	14	198	15	197	15
Unaged	5	55.6	4	44.4	9	100.0	135	25	145	28	139	27	209	11	214	9	211	11

Table 13. Age and sex composition, mean weight-at-age, and mean length-at-age of Pacific herring sampled from the harvest of the commercial purse seine sac roe fishery at Granite Bay, North Shore area, Prince William Sound, Alaska, 21 April 1988.

Age	Age and Sex Composition						Weight (g)						Standard Length (mm)					
	Male		Female		Combined		Male		Female		Combined		Male		Female		Combined	
	n	%	n	%	n	%	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
3	3	1.0	2	0.7	5	1.7	63	7	66	7	64	7	172	6	171	2	172	5
4	126	42.9	112	38.1	238	81.0	88	12	96	12	92	13	189	8	193	9	191	9
5	7	2.4	10	3.4	17	5.8	119	17	115	18	116	17	206	8	205	8	205	8
6	4	1.4	4	1.4	8	2.7	135	27	132	22	134	25	214	11	218	9	216	10
7	8	2.7	7	2.4	15	5.1	131	21	160	16	144	23	213	11	223	7	217	11
8	3	1.0	5	1.7	8	2.7	146	5	170	12	161	15	225	4	225	5	225	4
9	0	0.0	0	0.0	0	0.0												
10	1	0.3	0	0.0	1	0.3	191				191		243				243	
11	1	0.3	1	0.3	2	0.7	165		160		163	3	245		227		236	9
Total	153	52.0	141	48.0	294	100.0	95	23	104	25	99	24	193	14	197	13	195	14
Unaged	3	50.0	3	50.0	6	100.0	89	7	105	34	97	26	195	4	198	19	197	14

Table 14. Age and sex composition, mean weight-at-age, and mean length-at-age of Pacific herring sampled from the harvest of the commercial purse seine sac roe fishery at Unakwik Inlet, North Shore area, Prince William Sound, Alaska, 21 April 1988.

Age	Age and Sex Composition						Weight (g)						Standard Length (mm)					
	Male		Female		Combined		Male		Female		Combined		Male		Female		Combined	
	n	%	n	%	n	%	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
4	92	31.4	82	28.0	174	59.4	96	13	104	14	100	14	192	9	196	8	194	8
5	12	4.1	11	3.8	23	7.8	128	25	126	22	127	24	207	12	208	13	207	12
6	8	2.7	6	2.0	14	4.8	161	21	172	17	166	20	225	7	227	6	226	7
7	27	9.2	11	3.8	38	13.0	163	21	163	24	163	22	224	9	225	10	225	9
8	17	5.8	16	5.5	33	11.3	162	26	179	22	170	26	225	13	230	9	227	11
9	3	1.0	0	0.0	3	1.0	179	9			179	9	234	6			234	6
10	0	0.0	0	0.0	0	0.0												
11	3	1.0	0	0.0	3	1.0	193	16			193	16	239	5			239	5
12	2	0.7	3	1.0	5	1.7	197	30	209	28	204	29	242	10	243	9	242	10
Total	164	56.0	129	44.0	293	100.0	124	38	126	36	125	37	206	19	206	17	206	18
Unaged	4	57.1	3	42.9	7	100.0	138	28	177	7	155	29	214	12	230	5	221	12

Table 15. Estimates of the contributions of each age and year class to the Pacific herring harvested by the commercial purse seine sac roe fishery in Prince William Sound, Alaska, 22 April 1988.

Year Class	Age Class	Number Sampled	Mean Weight (g)	Mean Standard Length (mm)	Harvest by Age Class			
					Weight (Tonne)	Percent by Weight	Number of Fish (x 1,000)	Percent by Number
1985	3	8	68	176	32.6	0.8	479.1	1.3
1984	4	444	93	193	2,472.7	61.1	26,588.5	72.2
1983	5	30	122	210	219.2	5.4	1,796.5	4.9
1982	6	17	144	220	146.6	3.6	1,018.0	2.8
1981	7	64	158	225	605.5	15.0	3,832.6	10.4
1980	8	36	177	235	381.6	9.4	2,155.8	5.9
1979	9	7	190	240	79.6	2.0	419.2	1.1
1978	10	3	193	241	34.7	0.9	179.7	0.5
1977	11	4	195	241	46.7	1.2	239.5	0.7
1976	12	2	217	252	26.0	0.6	119.8	0.3
Total		615	110	202	4,045.2	100.0	36,828.7	100.0

Table 16. Age and sex composition, mean weight-at-age, and mean length-at-age of Pacific herring sampled from the harvest of the commercial purse seine sac roe fishery at the North Shore area, Prince William Sound, Alaska, 22 April 1988.

Age	Age and Sex Composition						Weight (g)						Standard Length (mm)					
	Male		Female		Combined		Male		Female		Combined		Male		Female		Combined	
	n	%	n	%	n	%	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
3	6	1.0	2	0.3	8	1.3	65	10	76	2	68	10	174	6	182	3	176	6
4	225	36.6	219	35.6	444	72.2	90	13	97	14	93	14	192	9	195	9	193	9
5	15	2.4	15	2.4	30	4.9	115	14	129	20	122	19	208	7	212	9	210	9
6	6	1.0	11	1.8	17	2.8	142	20	145	20	144	20	220	10	221	6	220	8
7	32	5.2	32	5.2	64	10.4	154	16	161	21	158	19	223	8	226	9	225	8
8	18	2.9	18	2.9	36	5.9	171	16	182	25	177	21	233	7	237	8	235	8
9	4	0.7	3	0.5	7	1.1	177	11	206	30	190	26	238	2	242	7	240	5
10	3	0.5	0	0.0	3	0.5	193	11			193	11	241	3			241	3
11	3	0.5	1	0.2	4	0.7	179	32	243		195	39	238	6	247		241	7
12	0	0.0	2	0.3	2	0.3			217	25	217	25			252	9	252	9
Total	312	50.7	303	49.3	615	100.0	106	33	115	35	110	35	200	18	203	17	202	18
Unaged	7	46.7	8	53.3	15	100.0	112	30	110	37	111	34	205	15	198	20	201	18

Table 17. Estimates of the contributions of each age and year class to the Pacific herring harvested by the commercial purse seine sac roe fishery in Prince William Sound, Alaska, 21 - 22 April 1988.

Year Class	Age Class	Mean Weight (g)	Harvest by Age Class			
			Weight (tonnes)	Percent by Weight	Number of Fish (x 1,000)	Percent by Number
1985	3	67	53.5	0.7	796.1	1.2
1984	4	94	4,335.3	60.5	45,990.9	71.1
1983	5	122	478.3	6.7	3,920.6	6.1
1982	6	148	314.1	4.4	2,127.6	3.3
1981	7	158	998.8	13.9	6,337.1	9.8
1980	8	173	679.8	9.5	3,931.2	6.1
1979	9	188	108.5	1.5	577.7	0.9
1978	10	196	47.5	0.7	243.1	0.4
1977	11	191	82.1	1.1	429.8	0.7
1976	12	210	65.0	0.9	310.0	0.5
Total		111	7,163.0	100.0	64,664.1	100.0

Table 18. Estimates of the contributions of each age and year class to the Pacific herring harvested by the commercial gill net sac roe fishery in Prince William Sound, Alaska, 23 April 1988.

Year Class	Age Class	Number Sampled	Mean Weight (g)	Mean Standard Length (mm)	Harvest by Age Class			
					Weight (tonnes)	Percent by Weight	Number of Fish (x 1,000)	Percent by Number
1984	4	11	125	206	4.6	1.4	37.2	1.9
1983	5	21	136	213	9.7	3.0	71.0	3.7
1982	6	48	153	221	24.8	7.6	162.2	8.5
1981	7	200	164	225	110.9	34.1	676.1	35.4
1980	8	180	174	229	105.9	32.6	608.4	31.9
1979	9	39	191	235	25.2	7.8	131.8	6.9
1978	10	24	199	240	16.1	5.0	81.1	4.2
1977	11	21	188	235	13.3	4.1	71.0	3.7
1976	12	21	202	241	14.3	4.4	71.0	3.7
Total		565	170	227	324.9	100.0	1,909.8	100.0

Table 19. Age and sex composition, mean weight-at-age, and mean length-at-age of Pacific herring sampled from the harvest of the commercial gill net sac roe fishery at the North Shore area , Prince William Sound, Alaska, 23 April 1988.

Age	Age and Sex Composition						Weight (g)						Standard Length (mm)					
	Male		Female		Combined		Male		Female		Combined		Male		Female		Combined	
	n	%	n	%	n	%	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
4	5	0.9	6	1.1	11	1.9	120	10	129	5	125	9	205	6	206	4	206	5
5	9	1.6	12	2.1	21	3.7	134	10	138	15	136	13	213	5	213	9	213	7
6	25	4.4	23	4.1	48	8.5	150	16	157	12	153	15	219	8	224	6	221	7
7	115	20.4	85	15.0	200	35.4	161	16	168	19	164	18	224	7	226	8	225	8
8	98	17.3	82	14.5	180	31.9	170	19	178	21	174	20	228	8	230	7	229	8
9	24	4.2	15	2.7	39	6.9	186	19	200	20	191	21	235	7	237	7	235	7
10	12	2.1	12	2.1	24	4.2	201	25	196	26	199	25	240	7	240	8	240	8
11	8	1.4	13	2.3	21	3.7	178	23	195	17	188	21	232	11	237	9	235	10
12	9	1.6	12	2.1	21	3.7	190	15	210	21	202	21	239	4	243	7	241	6
Total	305	54.0	260	46.0	565	100.0	166	23	174	26	170	24	226	10	229	10	227	10
Unaged	19	54.3	16	45.7	35	100.0	164	25	164	26	164	25	224	10	224	12	224	11

Table 20. Age and sex composition, mean weight-at-age, and mean length-at-age of Pacific herring sampled from the harvest of the commercial gill net (2 1/8" mesh) sac roe fishery at the North Shore area, Prince William Sound, Alaska, 23 April 1988.

Age	Age and Sex Composition						Weight (g)						Standard Length (mm)					
	Male		Female		Combined		Male		Female		Combined		Male		Female		Combined	
	n	%	n	%	n	%	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
4	3	5.5	4	7.3	7	12.7	113	3	127	4	121	7	202	2	203	3	203	3
5	4	7.3	6	10.9	10	18.2	127	7	126	11	127	10	210	3	206	6	208	6
6	5	9.1	0	0.0	5	9.1	151	12			151	12	220	7			220	7
7	8	14.5	2	3.6	10	18.2	153	19	170	30	157	23	221	8	225	12	222	9
8	10	18.2	7	12.7	17	30.9	154	20	167	14	159	19	221	10	226	4	223	9
9	1	1.8	2	3.6	3	5.5	185		220	1	208	17	235		247	6	243	7
10	0	0.0	2	3.6	2	3.6			187	1	187	1			233	9	233	9
11	1	1.8	0	0.0	1	1.8	134				134		215				215	
Total	32	58.2	23	41.8	55	100.0	146	22	156	32	150	27	218	10	219	15	219	13
Unaged	3	60.0	2	40.0	5	100.0	132	19	121	7	127	16	211	12	200	5	207	11

Table 21. Age and sex composition, mean weight-at-age, and mean length-at-age of Pacific herring sampled from the harvest of the commercial gill net (2 1/4" mesh) sac roe fishery at the North Shore area, Prince William Sound, Alaska, 23 April 1988.

Age	Age and Sex Composition						Weight (g)						Standard Length (mm)					
	Male		Female		Combined		Male		Female		Combined		Male		Female		Combined	
	n	%	n	%	n	%	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
4	1	0.3	2	0.6	3	0.9	122		135	4	130	7	205		211	2	209	3
5	4	1.2	5	1.5	9	2.6	139	9	152	6	146	10	212	4	220	4	217	6
6	11	3.2	18	5.3	29	8.5	144	12	157	13	152	14	217	4	224	6	221	7
7	64	18.8	55	16.1	119	34.9	160	16	166	21	163	18	224	7	226	8	225	7
8	61	17.9	55	16.1	116	34.0	171	18	180	21	175	20	228	7	231	7	230	7
9	11	3.2	8	2.3	19	5.6	192	18	197	21	194	19	234	9	236	6	235	8
10	8	2.3	4	1.2	12	3.5	195	16	185	29	192	22	239	5	238	6	239	5
11	6	1.8	11	3.2	17	5.0	187	16	194	16	191	16	236	9	237	9	237	9
12	7	2.1	10	2.9	17	5.0	191	17	207	21	200	21	239	5	242	6	241	6
Total	173	50.7	168	49.3	341	100.0	168	22	175	25	171	24	227	9	229	9	228	9
Unaged	11	57.9	8	42.1	19	100.0	175	22	172	23	174	22	228	8	229	7	228	7

Table 22. Estimates of the contributions of each age and year class to the Pacific herring which contributed spawn to the commercial wild spawn-on-kelp fishery in Valdez Arm, Prince William Sound, Alaska, 29 April 1988.

Year Class	Age Class	Number Sampled	Mean Weight (g)	Mean Standard Length (mm)	Utilization by Age Class			
					Weight (tonnes)	Percent by Weight	Number of Fish (x 1,000)	Percent by Number
1986	2	1	50	164	0.3	0.1	5.6	0.2
1985	3	5	61	172	1.7	0.7	28.0	1.1
1984	4	324	84	193	152.5	59.9	1,815.3	68.9
1983	5	40	93	199	20.8	8.1	224.1	8.5
1982	6	12	116	214	7.8	3.0	67.2	2.6
1981	7	33	144	226	26.6	10.4	184.9	7.0
1980	8	38	137	226	29.2	11.7	212.9	8.1
1979	9	5	164	229	4.6	1.8	28.0	1.1
1978	10	7	169	238	6.6	2.6	39.2	1.5
1977	11	3	163	241	2.7	1.1	16.8	0.6
1976	12	2	167	238	1.9	0.7	11.2	0.4
Total		470	96	200	254.8	100.0	2,633.3	100.0

Table 23. Age and sex composition, mean weight-at-age, and mean length-at-age of Pacific herring sampled from test fish purse seine catches at Valdez Arm, Prince William Sound, Alaska, 24 April 1988^a.

Age	Age and Sex Composition						Weight (g)						Standard Length (mm)					
	Male		Female		Combined		Male		Female		Combined		Male		Female		Combined	
	n	%	n	%	n	%	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
2	1	0.2	0	0.0	1	0.2	50				50		164				164	
3	3	0.6	2	0.4	5	1.1	57	3	67	19	61	13	168	3	179	17	172	12
4	202	43.0	122	26.0	324	68.9	81	12	89	14	84	13	192	9	195	8	193	9
5	22	4.7	18	3.8	40	8.5	91	16	96	12	93	14	199	11	200	8	199	10
6	10	2.1	2	0.4	12	2.6	115	15	118	8	116	14	213	8	218	3	214	7
7	21	4.5	12	2.6	33	7.0	135	21	158	20	144	23	224	12	229	9	226	11
8	26	5.5	12	2.6	38	8.1	135	24	144	23	137	24	225	13	227	8	226	11
9	2	0.4	3	0.6	5	1.1	180	20	154	22	164	25	239	6	223	12	229	13
10	4	0.9	3	0.6	7	1.5	163	15	176	37	169	28	239	6	236	13	238	10
11	2	0.4	1	0.2	3	0.6	154	10	183		163	16	237	7	250		241	8
12	2	0.4	0	0.0	2	0.4	167	8			167	8	238	3			238	3
Total	295	62.8	175	37.2	470	100.0	94	29	101	30	96	29	200	17	201	16	200	17
Unaged	4	66.7	2	33.3	6	100.0	111	42	107	27	110	38	206	22	208	14	207	20

^a Sampled herring were caught by a one-strip purse seine from the research vessel R.V. Montague. The sample was a pooled sample taken from Freemantle Bay, Sawmill Bay, and Johnson Cove.

Table 24. Estimates of the contributions of each age and year class to the Pacific herring which contributed spawn to the commercial wild spawn-on-kelp fishery in Fairmont Bay, Prince William Sound, Alaska, 30 April 1988.

Year Class	Age Class	Number Sampled	Mean Weight (g)	Mean Standard Length (mm)	Utilization by Age Class			
					Weight (tonnes)	Percent by Weight	Number of Fish (x 1,000)	Percent by Number
1985	3	22	70	176	3.5	0.8	49.6	1.3
1984	4	1,174	95	193	251.4	56.3	2,646.3	67.2
1983	5	123	118	205	32.7	7.3	277.3	7.0
1982	6	66	146	221	21.7	4.9	148.8	3.8
1981	7	177	158	224	63.0	14.1	399.0	10.1
1980	8	132	169	230	50.3	11.3	297.5	7.6
1979	9	20	185	239	8.3	1.9	45.1	1.1
1978	10	9	201	245	4.1	0.9	20.3	0.5
1977	11	14	198	242	6.2	1.4	31.6	0.8
1976	12	11	203	244	5.0	1.1	24.8	0.6
Total		1,748	113	202	446.3	100.0	3,940.2	100.0

Table 25. Age and sex composition, mean weight-at-age, and mean length-at-age of Pacific herring sampled from test fish purse seine catches at Fairmont Bay, North Shore area, Prince William Sound, Alaska, 18 April 1988.

Age	Age and Sex Composition						Weight (g)						Standard Length (mm)					
	Male		Female		Combined		Male		Female		Combined		Male		Female		Combined	
	n	%	n	%	n	%	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
3	2	0.4	2	0.4	4	0.7	63	5	104	19	84	25	174	5	205	10	190	17
4	148	27.0	144	26.3	292	53.3	95	17	105	17	100	18	195	10	200	9	198	9
5	22	4.0	27	4.9	49	8.9	111	17	116	17	114	17	205	8	201	36	203	27
6	9	1.6	19	3.5	28	5.1	142	30	155	23	151	26	222	12	226	11	225	11
7	44	8.0	28	5.1	72	13.1	160	23	161	23	161	23	227	10	226	11	227	10
8	41	7.5	32	5.8	73	13.3	161	25	172	26	166	26	228	11	231	11	229	11
9	7	1.3	4	0.7	11	2.0	172	49	200	20	182	43	234	23	251	5	240	20
10	4	0.7	0	0.0	4	0.7	206	10			206	10	247	8			247	8
11	3	0.5	4	0.7	7	1.3	193	11	217	15	207	18	241	2	248	10	245	9
12	3	0.5	5	0.9	8	1.5	180	23	208	9	198	21	240	15	244	6	243	11
Total	283	51.6	265	48.4	548	100.0	123	40	129	38	125	39	209	19	211	21	210	20
Unaged	6	50.0	6	50.0	12	100.0	104	32	131	37	117	37	198	17	211	17	204	18

Table 26. Estimates of the contributions of each age and year class to the Pacific herring which contributed spawn to the commercial wild spawn-on-kelp fishery in Prince William Sound, Alaska, 29-30 April 1988.

Year Class	Age Class	Mean Weight (g)	Utilization by Age Class			
			Weight (tonnes)	Percent by Weight	Number of Fish (x 1,000)	Percent by Number
1986	2	50	0.3	0.0	5.6	0.1
1985	3	67	5.2	0.7	77.6	1.2
1984	4	91	403.9	57.6	4,461.6	67.9
1983	5	107	53.6	7.6	501.4	7.6
1982	6	137	29.5	4.2	216.0	3.3
1981	7	154	89.7	12.8	583.9	8.9
1980	8	156	79.5	11.3	510.4	7.8
1979	9	177	12.9	1.8	73.1	1.1
1978	10	180	10.7	1.5	59.5	0.9
1977	11	186	9.0	1.3	48.4	0.7
1976	12	192	6.9	1.0	36.0	0.5
Total		107	701.1	100.0	6,573.5	100.0

Table 27. Estimates of the contributions of each age and year class to the Pacific herring utilized in the commercial pound spawn-on-kelp fishery in Valdez Arm, Prince William Sound, Alaska, 12 - 23 April 1988.

Year Class	Age Class	Number Sampled	Mean Weight (g)	Mean Standard Length (mm)	Utilization by Age Class			
					Weight (tonnes)	Percent by Weight	Number of Fish (x 1,000)	Percent by Number
1985	3	8	71	176	14.7	1.0	207.2	1.4
1984	4	484	90	189	1,128.1	80.0	12,534.9	84.8
1983	5	28	103	198	74.7	5.3	725.2	4.9
1982	6	8	105	186	21.8	1.5	207.2	1.4
1981	7	22	155	222	88.3	6.3	569.8	3.9
1980	8	16	148	217	61.3	4.3	414.4	2.8
1979	9	4	163	222	16.9	1.2	103.6	0.7
1978	10	1	187	185	4.8	0.3	25.9	0.2
Total		571	95	191	1,410.7	100.0	14,788.1	100.0

Table 28. Age and sex composition, mean weight-at-age, and mean length-at-age of Pacific herring sampled from the herring utilized in the pound fishery at Galena Bay, Prince William Sound, Alaska, 16 April 1988.

Age	Age and Sex Composition						Weight (g)						Standard Length (mm)					
	Male		Female		Combined		Male		Female		Combined		Male		Female		Combined	
	n	%	n	%	n	%	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
3	2	0.7	2	0.7	4	1.4	71	5	72	2	71	3	172	4	179	2	175	4
4	107	38.5	121	43.5	228	82.0	92	17	97	13	94	15	191	9	191	8	191	8
5	7	2.5	6	2.2	13	4.7	104	22	115	13	109	19	199	13	204	7	201	11
6	3	1.1	2	0.7	5	2.1	113	14	142	8	120	19	173	40	209	3	191	34
7	7	2.5	9	3.2	16	5.8	127	17	178	16	156	30	212	8	228	7	221	11
8	5	1.8	4	1.4	9	3.2	173	25	173	12	173	20	228	7	231	6	229	6
9	0	0.0	2	0.7	2	0.7			187	21	187	21			235	1	235	1
10	0	0.0	1	0.4	1	0.4			87		87				185		185	
Total	131	47.1	147	52.9	278	100.0	98	25	106	28	102	27	194	14	196	14	195	14
Unaged	11	68.8	5	31.3	16	100.0	108	27	109	19	108	25	202	17	197	9	200	15

Table 29. Age and sex composition, mean weight-at-age, and mean length-at-age of Pacific herring sampled from herring utilized in the pound spawn-on-kelp fishery at Virgin Bay, Prince William Sound, Alaska, 16 April 1988.

Age	Age and Sex Composition						Weight (g)						Standard Length (mm)					
	Male		Female		Combined		Male		Female		Combined		Male		Female		Combined	
	n	%	n	%	n	%	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
3	3	1.0	1	0.3	4	1.4	74	7	56		70	10	182	7	162		177	10
4	127	43.3	129	44.0	256	87.4	84	19	91	22	87	20	186	11	188	12	187	12
5	6	2.0	9	3.1	15	5.1	100	31	97	13	98	22	196	18	195	10	195	14
6	2	0.7	1	0.3	3	1.0	85	3	56		75	14	185	1	162		177	11
7	2	0.7	4	1.4	6	2.0	168	10	146	31	153	27	230	8	220	16	224	14
8	6	2.0	1	0.3	7	2.4	118	38	98		115	36	202	20	198		201	18
9	1	0.3	1	0.3	2	0.7	192		84		138	54	233		183		208	25
Total	147	50.2	146	49.8	293	100.0	88	25	92	23	90	24	188	14	189	14	188	14
Unaged	2	28.6	5	71.4	7	100.0	70	4	93	10	86	14	179	4	194	5	189	8

Table 30. Estimates of the contribution of each age and year class to the Pacific herring harvested and utilized by the commercial sac roe and spawn-on-kelp fisheries in Prince William Sound, Alaska, 1988.

Year Class	Age Class	Mean Weight (g)	Harvest by Age Class			
			Weight (tonnes)	Percent by Weight	Number of Fish (x 1,000)	Percent by Number
1986	2	50	0.3	0.0	5.6	0.0
1985	3	68	73.4	0.8	1,080.9	1.2
1984	4	93	5,872.0	61.2	63,024.6	71.7
1983	5	118	616.2	6.4	5,218.1	5.9
1982	6	144	390.2	4.1	2,713.1	3.1
1981	7	158	1,287.6	13.4	8,166.8	9.3
1980	8	170	926.5	9.7	5,464.5	6.2
1979	9	185	163.5	1.7	886.2	1.0
1978	10	193	79.2	0.8	409.6	0.5
1977	11	190	104.4	1.1	549.1	0.6
1976	12	207	86.2	0.9	417.0	0.5
Total		109	9,599.7	100.0	87,935.5	100.0

Table 31. Spawning biomass estimates and indices, by area, for Pacific herring in Prince William Sound, Alaska, 1988.

Survey Area	Peak Aerial Survey Date ^b	Spawning Biomass Estimates ^a		Observed Kilometers of Spawning ^d	Biomass of Herring per Kilometer (Tonne) ^a		
		Peak Aerial Survey (tonnes)	Spawn Deposition (tonnes) ^c		Aerial Survey Estimate	Spawn Deposition Estimate	Biomass Ratio ^e
Montague Island area							
Montague Island	14 & 19 April	12,228.9 ^f					
Green Island		0.0					
Area Total		12,228.9	29,764.3	133.5	91.6	223.0	2.43
Naked Island area							
Perry Island	19 April	0.0					
Naked Island Group		1,315.4					
Knight Island area		0.0					
Area Total		1,315.4	12,505.5	30.1	43.7	415.5	9.51
Northeast Shore area							
Port Gravina	28 March	526.2					
Port Fidalgo	6 & 24 April	127.0 ^f					
Tatitlek area	21 & 29 April	444.5 ^f					
Valdez Arm	5 & 22 April	5,288.9 ^f					
Area Total		6,386.6	6,688.9	166.8	38.3	40.1	1.05
North Shore area							
Pt. Freemantle-Granite Pt.	28 Mar, 8 & 22 April	861.8 ^f					
Granite Pt.-Esther Pass	8 & 22 April, 1 May	10,296.6 ^f					
Area Total		11,158.4	4,846.2	50.0	223.2	96.9	0.43
All Areas Combined		31,089.3	53,804.9	381.4	81.5	141.1	1.73

^a 1.0 tonnes = 1.10231 tons.

^b Date(s) the peak biomass observations were made.

^c Pacific herring spawning biomass estimates were made based on a spawn deposition survey conducted 30 April through 8 May 1988.

^d 1 kilometer = 0.6211 miles.

^e Biomass ratio was the spawn deposition spawning biomass estimate divided by the peak aerial survey spawning biomass estimate.

^f Aerial estimates that were based on more than one peak or date.

Table 32. Pacific herring biomass estimates from aerial surveys by area and date, Prince William Sound, 1988.

Date	Southeast Shore area		Northeast Shore area			North Shore area		Naked Island area		Montague Island area	Daily Total	Date
	Simpson	Port	Port	Tatitlek	Valdez	Freemantle	Granite Pt.	Naked	Knight	Montague		
	Islands	Gravina	Fidalgo	area	Arm & Port	Granite Pt.	Esther Pass.	Island	Island	Island		
03/18	0	0	0	0	0	0	0	0	0	0	0	03/18
03/19	0	0	0	0	0	0	0	0	0	0	0	03/19
03/20	0	0	0	0	0	0	0	0	0	0	0	03/20
03/21	0	0	0	0	0	0	0	0	0	0	0	03/21
03/22	0	0	0	0	0	0	0	0	0	0	0	03/22
03/23	0	0	0	0	0	0	0	0	0	0	0	03/23
03/24	0	0	0	0	0	0	0	0	0	0	0	03/24
03/25	0	0	0	0	0	0	0	0	0	0	0	03/25
03/26	0	0	0	0	0	0	0	0	0	0	0	03/26
03/27	0	0	0	0	0	0	0	0	0	0	0	03/27
03/28	0	526.2 ^a	0	0	0	9.1	0	0	0	0	535.2	03/28
03/29	0	0	0	0	0	0	0	0	0	0	0	03/29
03/30	0	18.1	0	0	0	0	0	0	0	0	18.1	03/30
03/31	0	0	0	0	0	0	0	0	0	0	0	03/31
04/01	0	0	0	0	0	0	0	0	0	0	0	04/01
04/02	0	0	0	0	0	0	0	0	0	0	0	04/02
04/03	0	0	0	0	0	0	0	0	0	0	0	04/03
04/04	0	0	0	0	0	0	0	0	0	0	0	04/04
04/05	0	0	0	0	72.6 ^a	0	0	0	0	0	72.6	04/05
04/06	0	9.1	72.6 ^a	0	18.1	0	163.3	0	0	0	263.1	04/06
04/07	0	0	0	0	0	0	0	0	0	0	0	04/07
04/08	0	0	18.1	0	63.5	362.9 ^a	1,342.6 ^a	0	0	0	1,787.2	04/08
04/09	0	0	0	0	9.1	127.0	870.9	0	0	0	1,007.0	04/09
04/10	0	0	0	0	0	0	0	0	0	0	0	04/10
04/11	0	0	0	0	0	0	0	0	0	0	0	04/11
04/12	0	0	0	0	0	0	0	0	0	0	0	04/12
04/13	0	0	0	0	0	0	36.3	0	0	0	36.3	04/13
04/14	0	0	0	72.6	0	0	0	0	0	3,665.0 ^a	3,737.6	04/14
04/15	0	0	0	0	0	0	0	0	0	0	0	04/15
04/16	0	0	0	0	0	0	0	72.6	0	639.6	712.1	04/16
04/17	0	0	0	63.5	0	0	0	54.4	0	771.1	889.0	04/17
04/18	0	0	0	0	0	0	653.2	181.4	0	1,025.1	1,859.7	04/18
04/19	0	0	0	72.6	36.3	0	90.7	1,315.4 ^a	0	8,563.8 ^a	10,078.8	04/19
04/20	0	0	0	81.6	272.2	0	6,096.3	843.7	0	2,077.5	9,371.2	04/20
04/21	0	0	0	417.3 ^a	2,413.1	0	6,132.6	1,034.2	0	1,605.7	11,602.9	04/21
04/22	0	0	0	0	5,216.3 ^a	489.9 ^a	8,836.0 ^a	0	0	36.3	14,578.5	04/22
04/23	0	0	0	0	0	0	3,002.8	0	0	0	3,002.8	04/23
04/24	0	0	54.4 ^a	0	0	0	997.9	0	0	0	1,052.3	04/24
04/25	0	0	0	0	0	0	0	0	0	0	0	04/25
04/26	0	0	0	0	0	0	0	0	0	0	0	04/26
04/27	0	0	0	0	0	0	0	0	0	0	0	04/27
04/28	0	0	0	0	0	0	0	0	0	0	0	04/28
04/29	0	0	0	27.2 ^a	0	0	99.8	0	0	90.7	217.7	04/29
04/30	0	0	0	0	0	0	0	0	0	0	0	04/30
05/01	0	0	0	0	0	0	117.9 ^a	0	0	0	117.9	05/01
05/02	0	0	0	0	0	0	0	0	0	0	0	05/02
05/03	0	0	0	0	0	0	0	0	0	0	0	05/03
05/04	0	0	0	0	0	0	0	0	0	0	0	05/04
05/05	0	0	0	0	0	0	0	0	0	0	0	05/05
05/06	0	0	0	0	0	0	0	0	0	0	0	05/06
05/07	0	0	0	0	0	0	0	0	0	0	0	05/07
05/08	0	0	0	0	0	0	0	0	0	0	0	05/08
05/09	0	0	0	0	0	0	0	0	0	0	0	05/09
Area												
Totals	0.0	553.4	145.1	734.8	8,101.2	988.8	28,440.3	3,501.7	0.0	18,474.8	60,940.2	
Peak Aerial												
Estimates	0.0	526.2	127.0	444.5	5,288.9	861.8	10,296.6	1,315.4	0.0	12,228.9	31,089.3	

^a Indicates aerial estimates used in peak survey estimate.

Table 33. Estimated kilometers of spawning by Pacific herring based upon aerial survey observations, Prince William Sound, Alaska, 1988.

Date	Southeast Shore area					Northeast Shore area					Naked Island area		Montague Island area	Daily Total	Date
	Simpson		Port Gravina	Port Fidalgo	Tatitlek area	Arm & Port Valdez	North Shore area		Naked Island	Knight Island	Montague Island				
	Islands	Port					Freemantle Granite Pt.	Granite Pt. Esther Pass							
03/18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	03/18
03/19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	03/19
03/20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	03/20
03/21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	03/21
03/22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	03/22
03/23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	03/23
03/24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	03/24
03/25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	03/25
03/26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	03/26
03/27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	03/27
03/28	0	4.2	0	0	0	0	0	0	0	0	0	0	4.2	0	03/28
03/29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	03/29
03/30	0	2.6	0	0	0	0	0	0	0	0	0	0	2.6	0	03/30
03/31	0	0.5	0	0	0	0	0	0	0	0	0	0	0.5	0	03/31
04/01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	04/01
04/02	0	0	0	0.3	0	0	0	0	0	0	0	0	0.3	0	04/02
04/03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	04/03
04/04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	04/04
04/05	0	0	0.5	1.0	0	0	0	0	0	0	0	0	1.4	0	04/05
04/06	0	0	0	0.8	0	0	0	0	0	0	0	0	0.8	0	04/06
04/07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	04/07
04/08	0	0	0.8	0.3	0	0	0	0	0	0	0	0	1.1	0	04/08
04/09	0	0	3.2	0	0	0	0	0	0	0	0	0	3.2	0	04/09
04/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	04/10
04/11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	04/11
04/12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	04/12
04/13	0	0	0	2.3	0	0	0	0	0	0	0	0	2.3	0	04/13
04/14	0	0	0	1.6	0	0	0	0	0	0	0	0	1.6	0	04/14
04/15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	04/15
04/16	0	0	0	1.3	0.8	0	0	0	0	0	0	0	2.1	0	04/16
04/17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	04/17
04/18	0	0	0	2.4	1.6	0	0	0	0	0	0	0	4.0	0	04/18
04/19	0	0	0	3.5	1.9	0	0	0	0	0	3.2	8.7	0	0	04/19
04/20	0	0	0.3	3.4	6.4	0	2.7	1.6	0	12.4	26.9	0	0	0	04/20
04/21	0	0	0	3.9	4.0	0	3.7	6.4	0	17.4	35.4	0	0	0	04/21
04/22	0	0.3	0	16.1	12.9	0	0	5.3	1.0	20.4	56.0	0	0	0	04/22
04/23	0	0	0	25.0	24.6	0	9.2	16.7	0	28.2	103.7	0	0	0	04/23
04/24	0	0	0	10.0	26.4	4.8	18.8	0	0	6.6	66.7	0	0	0	04/24
04/25	0	0	0	0	0	0	0	0	0	6.4	6.4	0	0	0	04/25
04/26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	04/26
04/27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	04/27
04/28	0	0	0	0	0	0	1.0	0	0	31.7	32.7	0	0	0	04/28
04/29	0	0	0	0	0	0	2.1	0	0	7.1	9.2	0	0	0	04/29
04/30	0	0	0	1.9	0	0	2.9	0	0	0	4.8	0	0	0	04/30
05/01	0	0	0	1.9	0	0	4.8	0	0	0	6.8	0	0	0	05/01
05/02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	05/02
05/03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	05/03
05/04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	05/04
05/05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	05/05
05/06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	05/06
05/07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	05/07
05/08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	05/08
05/09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	05/09
Area Totals	0.0	7.6	4.8	75.7	78.7	4.8	45.2	30.1	1.0	133.5	381.4				
Percent of Totals	0.0%	2.0%	1.3%	19.8%	20.6%	1.3%	11.9%	7.9%	0.3%	35.0%	100.0%				

Table 34. Estimates of the contributions of each age and year class to the estimated spawning biomass (from spawn deposition survey) of Pacific herring in the Montague Island area, Prince William Sound, Alaska, 1988.

Year Class	Age Class	Number Sampled	Mean Weight (g)	Mean Standard Length (mm)	Biomass by Age Class			
					Weight (tonnes)	Percent by Weight	Number of Fish (x 1,000)	Percent by Number
1985	3	14	71	176	540.4	1.8	7,611.7	2.5
1984	4	495	93	193	25,028.8	84.1	269,126.5	87.1
1983	5	25	106	202	1,440.8	4.8	13,592.2	4.4
1982	6	13	143	219	1,010.7	3.4	7,068.0	2.3
1981	7	11	144	221	861.2	2.9	5,980.6	1.9
1980	8	6	167	227	544.8	1.8	3,262.1	1.1
1979	9	0			0.0	0.0	0.0	0.0
1978	10	1	104	205	56.5	0.2	543.7	0.2
1977	11	1	81	188	44.0	0.1	543.7	0.2
1976	12	2	218	245	237.0	0.8	1,087.4	0.4
Total		568	96	195	29,764.3	100.0	308,815.8	100.0

Table 35. Age and sex composition, mean weight-at-age, and mean length-at-age of Pacific herring sampled from test fish purse seine catches at Hanning Bay, Montague Island area, Prince William Sound, Alaska, 17 April 1988.

Age	Age and Sex Composition						Weight (g)						Standard Length (mm)					
	Male		Female		Combined		Male		Female		Combined		Male		Female		Combined	
	n	%	n	%	n	%	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
3	8	1.4	6	1.1	14	2.5	68	23	76	26	71	25	175	14	179	16	176	15
4	212	37.3	283	49.8	495	87.1	89	13	95	15	93	14	192	8	194	9	193	9
5	13	2.3	12	2.1	25	4.4	98	14	115	18	106	18	198	8	207	11	202	11
6	7	1.2	6	1.1	13	2.3	137	16	150	29	143	24	215	5	225	11	219	10
7	4	0.7	7	1.2	11	1.9	113	15	162	34	144	37	210	11	227	14	221	16
8	2	0.4	4	0.7	6	1.1	148	8	177	14	167	19	220	1	230	5	227	6
9	0	0.0	0	0.0	0	0.0												
10	0	0.0	1	0.2	1	0.2			104		104				205		205	
11	1	0.2	0	0.0	1	0.2	81				81		188				188	
12	2	0.4	0	0.0	2	0.4	218	26			218	26	245				245	4
Total	249	43.8	319	56.2	568	100.0	92	21	99	23	96	22	193	12	196	12	195	12
Unaged	21	65.6	11	34.4	32	100.0	88	13	110	37	96	26	192	9	202	17	195	13

Table 36. Age and sex composition, mean weight-at-age, and mean length-at-age of Pacific herring sampled from test fish purse seine catches at Montague Island area (Stockdale Harbor and Port Chalmers), Prince William Sound, Alaska, 16 April 1988.

Age	Age and Sex Composition						Weight (g)						Standard Length (mm)					
	Male		Female		Combined		Male		Female		Combined		Male		Female		Combined	
	n	%	n	%	n	%	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
2	1	0.2	2	0.4	3	0.5	35		43	4	41	7	140		150	7	148	9
3	113	20.5	57	10.3	170	30.8	56	9	55	10	55	10	164	9	164	9	164	9
4	243	44.0	87	15.8	330	59.8	71	10	76	14	72	12	178	9	181	11	179	9
5	12	2.2	9	1.6	21	3.8	83	7	77	21	79	17	188	5	181	18	183	15
6	5	0.9	1	0.2	6	1.9	141	20	131		134	23	218	8	217		216	9
7	7	1.3	5	0.9	12	2.2	140	35	138	30	139	33	214	16	216	14	215	15
8	5	0.9	3	0.5	8	1.4	162	18	194	13	174	23	230	5	235	7	232	7
9	1	0.2	1	0.2	2	0.4	193		212		203	10	239		239		239	
Total	387	70.1	165	29.9	552	100.0	71	22	74	29	71	24	176	15	177	18	176	16
Unaged	14	66.7	4	19.0	21	100.0	72	27	104	45	74	34	176	16	195	20	178	19

Table 37. Age and sex composition, mean weight-at-age, and mean length-at-age of Pacific herring sampled from test fish purse seine catches at Green Island, Prince William Sound, Alaska, 14 April 1988.

Age	Age and Sex Composition						Weight (g)						Standard Length (mm)					
	Male		Female		Combined		Male		Female		Combined		Male		Female		Combined	
	n	%	n	%	n	%	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
3	10	1.7	7	1.2	17	2.9	65	9	63	9	64	9	176	6	173	8	175	7
4	269	46.6	227	39.3	496	86.0	86	14	94	15	89	15	191	9	195	8	193	9
5	14	2.4	14	2.4	28	4.9	94	10	100	24	97	19	198	8	198	12	198	10
6	3	0.5	4	0.7	7	1.2	111	18	98	24	104	22	207	13	198	18	202	17
7	4	0.7	7	1.2	11	1.9	142	14	163	24	156	23	218	3	224	11	222	10
8	7	1.2	9	1.6	16	2.8	158	37	164	24	161	30	221	12	228	9	225	11
9	0	0.0	1	0.2	1	0.2			182		182				240		240	
10	0	0.0	0	0.0	0	0.0												
11	1	0.2	0	0.0	1	0.2	200				200		247				247	
Total	308	53.4	269	46.6	577	100.0	88	21	98	24	93	23	192	11	197	13	194	12
Unaged	13	56.5	10	43.5	23	100.0	83	10	115	35	97	29	189	7	205	17	196	15

Table 38. Estimates of the contributions of each age and year class to the estimated spawning biomass (from spawn deposition survey) of Pacific herring in the Naked Island area, Prince William Sound, Alaska, 1988.

Year Class	Age Class	Number Sampled	Mean Weight (g)	Mean Standard Length (mm)	Biomass by Age Class			
					Weight (tonnes)	Percent by Weight	Number of Fish (x 1,000)	Percent by Number
1985	3	10	63	170	134.6	1.1	2,136.9	1.8
1984	4	397	93	192	7,889.6	63.1	84,834.5	72.8
1983	5	38	115	205	933.8	7.5	8,120.2	7.0
1982	6	17	143	218	519.5	4.2	3,632.7	3.1
1981	7	39	158	225	1,316.8	10.5	8,333.9	7.2
1980	8	28	173	231	1,035.1	8.3	5,983.3	5.1
1979	9	11	187	236	439.6	3.5	2,350.6	2.0
1978	10	0			0.0	0.0	0.0	0.0
1977	11	2	222	248	94.9	0.8	427.4	0.4
1976	12	3	221	246	141.7	1.1	641.1	0.6
Total		545	107	199	12,505.5	100.0	116,460.4	100.0

Table 39. Age and sex composition, mean weight-at-age, and mean length-at-age of Pacific herring sampled from test fish purse seine catches at Naked Island area, McPherson Passage, Prince William Sound, Alaska, 19 April 1988.

Age	Age and Sex Composition						Weight (g)						Standard Length (mm)					
	Male		Female		Combined		Male		Female		Combined		Male		Female		Combined	
	n	%	n	%	n	%	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
3	4	0.7	6	1.1	10	1.8	65	5	63	7	63	6	171	5	170	9	170	7
4	201	36.9	196	36.0	397	72.8	91	12	95	16	93	14	191	8	192	8	192	8
5	16	2.9	22	4.0	38	7.0	110	23	119	17	115	20	203	13	207	9	205	11
6	9	1.7	8	1.5	17	3.1	136	23	150	19	143	23	216	10	219	9	218	10
7	18	3.3	21	3.9	39	7.2	152	23	164	24	158	24	222	9	227	11	225	10
8	14	2.6	14	2.6	28	5.1	163	30	183	17	173	26	229	8	233	10	231	9
9	3	0.6	8	1.5	11	2.0	182	16	189	19	187	19	234	9	236	5	236	6
10	0	0.0	0	0.0	0	0.0												
11	0	0.0	2	0.4	2	0.4			222	3	222	3			248	2	248	2
12	3	0.6	0	0.0	3	0.6	221	20			221	20	246	8			246	8
Total	268	49.2	277	50.8	545	100.0	104	31	111	36	107	34	197	16	200	18	199	17
Unaged	5	33.3	10	66.7	15	100.0	109	36	92	19	98	27	199	18	194	12	196	14

Table 40. Estimates of the contributions of each age and year class to the estimated spawning biomass (from spawn deposition survey) of Pacific herring in the Northeast Shore area, Prince William Sound Alaska, 1988.

Year Class	Age Class	Number Sampled	Mean Weight (g)	Mean Standard Length (mm)	Biomass by Age Class			
					Weight (tonnes)	Percent by Weight	Number of Fish (x 1,000)	Percent by Number
1985	3	8	71	176	69.0	1.0	972.5	1.4
1984	4	489	90	189	5,350.0	80.0	59,444.5	84.7
1983	5	28	103	198	350.6	5.2	3,403.8	4.9
1982	6	9	105	186	114.9	1.7	1,094.1	1.6
1981	7	22	155	222	414.5	6.2	2,674.4	3.8
1980	8	16	148	217	287.9	4.3	1,945.0	2.8
1979	9	4	163	222	79.3	1.2	486.3	0.7
1978	10	1	187	185	22.7	0.3	121.6	0.2
Total		577	95	191	6,688.9	100.0	70,142.0	100.0

Table 41. Age and sex composition, mean weight-at-age, and mean length-at-age of Pacific herring sampled from test fish purse seine catches at Galena Bay, Northeast Shore area, Prince William Sound, Alaska, 8 April 1988.

Age	Age and Sex Composition						Weight (g)						Standard Length (mm)					
	Male		Female		Combined		Male		Female		Combined		Male		Female		Combined	
	n	%	n	%	n	%	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
3	2	1.0	4	2.1	6	3.1	79	10	67	8	71	10	178	13	163	5	168	11
4	52	26.7	57	29.2	109	55.9	97	15	103	14	100	15	189	9	191	8	190	9
5	9	4.6	3	1.5	12	6.2	112	15	106	9	110	14	198	10	194	5	197	9
6	13	6.7	8	4.1	21	10.8	139	8	135	7	138	8	211	6	209	9	210	7
7	13	6.7	6	3.1	19	9.7	155	19	169	10	159	18	218	8	222	3	219	7
8	14	7.2	8	4.1	22	11.3	167	17	176	33	170	24	222	8	222	11	222	9
9	2	1.0	0	0.0	2	1.0	147	30			147	30	211	11			211	11
10	1	0.5	1	0.5	2	1.0	180		231		206	26	222		241		232	10
11	1	0.5	1	0.5	2	1.0	145		235		190	45	223		251		237	14
Total	107	54.9	88	45.1	195	100.0	121	33	119	36	120	34	201	16	198	17	200	17
Unaged	7	46.7	8	53.3	15	100.0	139	22	143	33	141	28	208	12	209	10	209	11

Table 42. Age and sex composition, mean weight-at-age, and mean length-at-age of Pacific herring sampled from test fish purse seine catches at Galena Bay, Northeast Shore area, Prince William Sound, Alaska, 9 April 1988.

Age	Age and Sex Composition						Weight (g)						Standard Length (mm)					
	Male		Female		Combined		Male		Female		Combined		Male		Female		Combined	
	n	%	n	%	n	%	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
3	6	1.0	7	1.2	13	2.3	62	10	69	6	66	8	164	8	168	6	166	7
4	101	17.7	116	20.4	217	38.1	91	13	101	19	96	17	186	8	190	10	189	9
5	18	3.1	26	4.6	44	7.7	121	22	120	17	121	19	201	8	202	9	202	9
6	13	2.3	24	4.2	37	6.5	136	24	147	19	143	22	210	11	211	9	211	10
7	64	11.2	46	8.1	110	19.3	147	22	167	21	155	24	215	10	221	9	217	10
8	55	9.6	50	8.8	105	18.4	168	22	176	25	171	24	222	8	225	10	223	9
9	8	1.4	8	1.4	16	2.8	172	12	185	31	179	24	225	6	230	9	227	8
10	7	1.2	6	1.0	13	2.3	197	17	193	22	195	20	235	6	232	8	233	7
11	4	0.7	4	0.7	8	1.4	190	8	189	4	189	6	229	3	234	3	231	4
12	2	0.3	5	0.9	7	1.2	224	19	224	25	224	24	239	2	238	6	238	5
Total	278	48.8	292	51.2	570	100.0	130	40	137	42	133	41	205	19	207	19	206	19
Unaged	11	40.7	16	59.3	27	100.0	149	36	161	40	156	39	213	20	218	19	216	19

Table 43. Estimates of the contributions of each age and year class to the estimated spawning biomass (from spawn deposition survey) of Pacific herring in the North Shore area, Prince William Sound, Alaska, 1988.

Year Class	Age Class	Number Sampled	Mean Weight (g)	Mean Standard Length (mm)	Biomass by Age Class			
					Weight (tonnes)	Percent by Weight	Number of Fish (x 1,000)	Percent by Number
1985	3	22	70	176	37.7	0.8	538.4	1.3
1984	4	1,174	95	193	2,729.7	56.3	28,733.4	67.2
1983	5	123	118	205	355.2	7.3	3,010.4	7.0
1982	6	66	146	221	235.8	4.9	1,615.3	3.8
1981	7	177	158	224	684.5	14.1	4,332.0	10.1
1980	8	132	169	230	546.0	11.3	3,230.7	7.6
1979	9	20	185	239	90.6	1.9	489.5	1.1
1978	10	9	201	245	44.3	0.9	220.3	0.5
1977	11	14	198	242	67.8	1.4	342.6	0.8
1976	12	11	203	244	54.7	1.1	269.2	0.6
Total		1,748	113	202	4,846.2	100.0	42,781.9	100.0

Table 44. Age and sex composition, mean weight-at-age, and mean length-at-age of Pacific herring sampled from test fish purse seine catches at Wells Bay, North Shore area, Prince William Sound, Alaska, 8 April 1988.

Age	Age and Sex Composition						Weight (g)						Standard Length (mm)					
	Male		Female		Combined		Male		Female		Combined		Male		Female		Combined	
	n	%	n	%	n	%	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
3	14	2.5	9	1.6	23	4.1	69	11	65	6	67	10	170	7	167	5	169	6
4	241	43.0	222	39.6	463	82.2	85	12	93	14	88	13	182	8	186	9	184	9
5	7	1.3	19	3.4	26	4.7	112	12	107	18	109	16	196	7	194	11	194	10
6	9	1.6	5	0.9	14	2.5	126	11	112	29	121	20	213	12	193	12	206	16
7	9	1.6	8	1.4	17	3.1	140	20	141	24	140	22	212	8	212	8	212	8
8	4	0.7	4	0.7	8	1.4	151	18	153	21	152	20	223	5	212	9	217	9
9	0	0.0	1	0.2	1	0.2			175		175				234		234	
10	0	0.0	1	0.2	1	0.2			197		197				223		223	
11	1	0.2	1	0.2	2	0.4	169		222		196	27	220		249		235	15
12	1	0.2	0	0.0	1	0.2	191				191		240				240	
Total	286	51.4	270	48.6	556	100.0	89	21	97	22	93	22	185	13	187	12	186	13
Unaged	20	50.0	20	50.0	40	100.0	103	31	92	19	98	27	193	19	185	12	189	16

Table 45. Age and sex composition, mean weight-at-age, and mean length-at-age of Pacific herring sampled from test fish purse seine catches at Olsen Bay, Prince William Sound, Alaska, 30 March 1988.

Age	Age and Sex Composition						Weight (g)						Standard Length (mm)					
	Male		Female		Combined		Male		Female		Combined		Male		Female		Combined	
	n	%	n	%	n	%	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
2	1	0.2	0	0.0	1	0.2	40				40		153				153	
3	51	8.8	10	1.7	61	10.5	54	6	55	5	54	6	165	8	170	5	166	8
4	220	37.9	84	14.5	304	52.4	73	14	79	16	75	15	182	10	183	11	182	10
5	34	5.9	25	4.3	59	10.2	87	20	93	19	90	19	191	12	192	11	192	12
6	31	5.3	15	2.6	46	7.9	109	22	121	26	113	24	203	11	210	12	205	12
7	56	9.7	25	4.3	81	14.0	129	27	135	20	131	25	212	12	215	9	213	11
8	16	2.8	9	1.6	25	4.3	146	20	140	19	144	20	223	8	218	10	221	9
9	3	0.5	0	0.0	3	0.5	155	21			155	21	223	8			223	8
Total	412	71.0	168	29.0	580	100.0	85	31	95	31	88	31	188	19	193	18	189	19
Unaged	14	70.0	6	30.0	20	100.0	77	19	99	30	84	25	184	12	194	18	187	15

Table 46. Estimates of the contribution of each age and year class to the estimated spawning biomass (from spawn deposition surveys) of Pacific herring in Prince William Sound, Alaska, 1988.

Year Class	Age Class	Mean Weight (g)	Biomass by Age Class			
			Weight (tonnes)	Percent by Weight	Number of Fish (x 1,000)	Percent by Number
1985	3	69	781.8	1.5	11,259.5	2.1
1984	4	93	40,998.0	76.2	442,138.8	82.2
1983	5	110	3,080.4	5.7	28,126.6	5.2
1982	6	140	1,880.9	3.5	13,410.1	2.5
1981	7	154	3,276.9	6.1	21,320.9	4.0
1980	8	167	2,413.7	4.5	14,421.1	2.7
1979	9	183	609.4	1.1	3,326.3	0.6
1978	10	140	123.6	0.2	885.5	0.2
1977	11	157	206.8	0.4	1,313.7	0.2
1976	12	217	433.4	0.8	1,997.7	0.4
Total		100	53,804.9	100.0	538,200.2	100.0

Table 47. Estimates of the contribution of each age and year class to the total escapement of Pacific herring in Prince William Sound, Alaska, 1988.

Year Class	Age Class	Mean Weight (g)	Escapement by Age Class ^a			
			Weight (tonnes)	Percent by Weight	Number of Fish (x 1,000)	Percent by Number
1986	2	50	0.3	0.0	5.6	0.0
1985	3	69	787.0	1.4	11,337.1	2.1
1984	4	93	41,401.9	76.0	446,600.4	82.0
1983	5	109	3,134.0	5.7	28,628.0	5.3
1982	6	140	1,910.4	3.5	13,626.1	2.5
1981	7	154	3,366.6	6.2	21,904.8	4.0
1980	8	167	2,493.2	4.6	14,931.6	2.7
1979	9	183	622.3	1.1	3,399.4	0.6
1978	10	142	134.2	0.2	945.0	0.2
1977	11	158	215.7	0.4	1,362.1	0.3
1976	12	216	440.3	0.8	2,033.7	0.4
Total		100	54,506.0	100.0	544,773.7	100.0

^a The escapement was the sum of the estimated spawning biomass from the spawn deposition surveys and the estimated utilization by the wild spawn-on-kelp fishery.

Table 48. Estimates of the contribution of each age and year class to the total spawning biomass of Pacific herring in Prince William Sound Alaska, 1988.

Year Class	Age Class	Mean Weight (g)	Total Spawning Biomass by Age Class			
			Weight (tonnes)	Percent by Weight	Number of Fish (x 1,000)	Percent by Number
1986	2	50	0.3	0.0	5.6	0.0
1985	3	69	855.2	1.3	12,340.4	2.0
1984	4	93	46,870.1	73.9	505,163.4	80.7
1983	5	111	3,696.6	5.8	33,344.7	5.3
1982	6	141	2,272.2	3.6	16,123.2	2.6
1981	7	155	4,564.6	7.2	29,487.7	4.7
1980	8	168	3,340.2	5.3	19,885.6	3.2
1979	9	183	772.9	1.2	4,212.5	0.7
1978	10	157	202.8	0.3	1,295.1	0.2
1977	11	167	311.2	0.5	1,862.8	0.3
1976	12	215	519.6	0.8	2,414.6	0.4
Total		101	63,404.6	100.0	626,135.7	100.0

Table 49. Estimates of the exploitation rate (by weight) of each age and year class and a summary of the contributions of each age and year class to the harvest, escapement, and total spawning biomass of Pacific herring in Prince William Sound, Alaska, 1988.

1988 Pacific Herring Harvest and Utilization (Tonne)										
Year Class	Age Class	1987 Food & Bait Fishery (Tonne) ^a	Sac Roe Fisheries		Spawn-on-Kelp Fisheries		1988 Harvest and Utilization	1988 Escapement (Tonne) ^b	1988 Total Spawning Biomass (Tonne) ^c	Estimated Exploitation Rate (by Weight)
			Purse Seine	Gill Net	Wild	Pound				
1986	2	114.7	0.0	0.0	0.3	0.0	0.3	0.3	0.3	100.0
1985	3	523.6	53.5	0.0	5.2	14.7	73.4	787.0	855.0	8.6
1984	4	203.2	4,335.4	4.6	403.9	1,128.1	5,872.0	41,401.9	46,870.3	12.5
1983	5	169.9	478.3	9.7	53.6	74.7	616.2	3,134.0	3,696.6	16.7
1982	6	50.9	314.1	24.8	29.5	21.8	390.2	1,910.4	2,271.2	17.2
1981	7	15.1	998.8	110.9	89.7	88.3	1,287.6	3,366.6	4,564.6	28.2
1980	8	1.7	679.8	105.9	79.5	61.3	926.5	2,493.2	3,340.2	27.7
1979	9	0.0	108.5	25.2	12.9	16.9	163.5	622.3	772.9	21.2
1978	10	0.0	47.5	16.1	10.7	4.8	79.2	134.3	202.8	39.1
1977	11	0.0	82.1	13.3	9.0	0.0	104.4	215.7	311.2	33.6
1976	12	0.0	65.0	14.3	6.9	0.0	86.2	440.3	519.6	16.6
Total		1,079.1	7,163.0	324.9	701.1	1,410.7	9,599.7	54,506.0	63,404.6	15.1

^a The age class of a Pacific herring in the food and bait fishery corresponds to a one-year older age class in the sac roe fishery. As an example, an age-2 fish in the food and bait fishery corresponds to an age-3 fish in the sac roe fishery. Therefore, the ages are correct for the food and bait fishery but the corresponding year class is one year earlier.

^b The escapement estimate was the sum of estimated spawning biomass from the spawn deposition survey and the estimated utilization by the wild spawn-on-kelp fishery. The utilization by the wild spawn-on-kelp fishery was included in both the harvest and escapement. The estimated utilization was included in the harvest because the eggs deposited were harvested in the fishery. However, the estimated utilization was also included in the escapement because the adult Pacific herring that deposited the eggs did escape the harvest and should return to spawn again in the future.

^c The total spawning biomass was the sum of the estimated escapement, the harvest by the sac roe fisheries, and the estimated utilization by the pound spawn-on-kelp fisheries. The estimated utilization by the wild spawn-on-kelp fishery was only included from the escapement and not from the harvest.

Table 50. Estimates of the exploitation rate (by number) of each age and year class and a summary of the contributions of each age and year class to the harvest, escapement, and total spawning biomass of Pacific herring in Prince William Sound, Alaska, 1988.

Number of Pacific Herring (x 1,000)										
1988 Sac Roe and Spawn-on-Kelp Fisheries										
Year Class	Age Class	1987 Food & Bait Fishery ^a	Sac Roe Fisheries		Spawn-on-Kelp Fisheries		1988 Harvest and Utilization	1988 Escapement ^b	1988 Total Spawning Biomass ^c	Estimated Exploitation Rate (by Number)
			Purse Seine	Gill Net	Wild	Pound				
1987	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1986	2	1,744.3	0.0	0.0	5.6	0.0	5.6	5.6	5.6	100.0
1985	3	6,461.3	796.1	0.0	77.6	207.2	1,080.9	11,337.1	12,340.4	8.8
1984	4	2,175.1	45,990.9	37.2	4,461.6	12,534.9	63,024.6	446,600.4	505,163.4	12.5
1983	5	1,666.7	3,920.6	71.0	501.4	725.2	5,218.1	28,628.0	33,344.7	15.6
1982	6	448.1	2,127.6	162.2	216.0	207.7	2,713.1	13,626.1	16,123.2	16.8
1981	7	131.5	6,337.1	676.0	583.9	569.8	8,166.8	21,904.8	29,487.7	27.7
1980	8	13.3	3,931.2	608.4	510.4	414.4	5,464.5	14,931.6	19,885.6	27.5
1979	9	0.0	577.7	131.8	73.1	103.6	886.2	3,399.4	4,212.5	21.0
1978	10	0.0	243.1	81.1	59.5	25.9	409.6	945.0	1,295.1	31.6
1977	11	0.0	429.8	71.0	48.4	0.0	549.1	1,362.1	1,862.8	29.5
1976	12	0.0	310.0	71.0	36.0	0.0	417.0	2,033.7	2,414.6	17.3
1975	13+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total		12,640.4	64,664.1	1,909.8	6,573.5	14,788.1	87,935.5	544,773.7	626,135.7	14.0

^a The age class of a Pacific herring in the food and bait fishery corresponds to a one-year older age class in the sac roe fishery. As an example, an age-2 fish in the food and bait fishery corresponds to an age-3 fish in the sac roe fishery. Therefore, the ages are correct for the food and bait fishery but the corresponding year class is one year earlier.

^b The escapement estimate was the sum of estimated spawning biomass from the spawn deposition survey and the estimated utilization by the wild spawn-on-kelp fishery. The utilization by the wild spawn-on-kelp fishery was included in both the harvest and escapement. The estimated utilization was included in the harvest because the eggs deposited were harvested in the fishery. However, the estimated utilization was also included in the escapement because the adult Pacific herring that deposited the eggs did escape the harvest and should return to spawn again in the future.

^c The total spawning biomass was the sum of the estimated escapement, the harvest by the sac roe fisheries, and the estimated utilization by the pound spawn-on-kelp fisheries. The estimated utilization by the wild spawn-on-kelp fishery was only included from the escapement and not from the harvest.

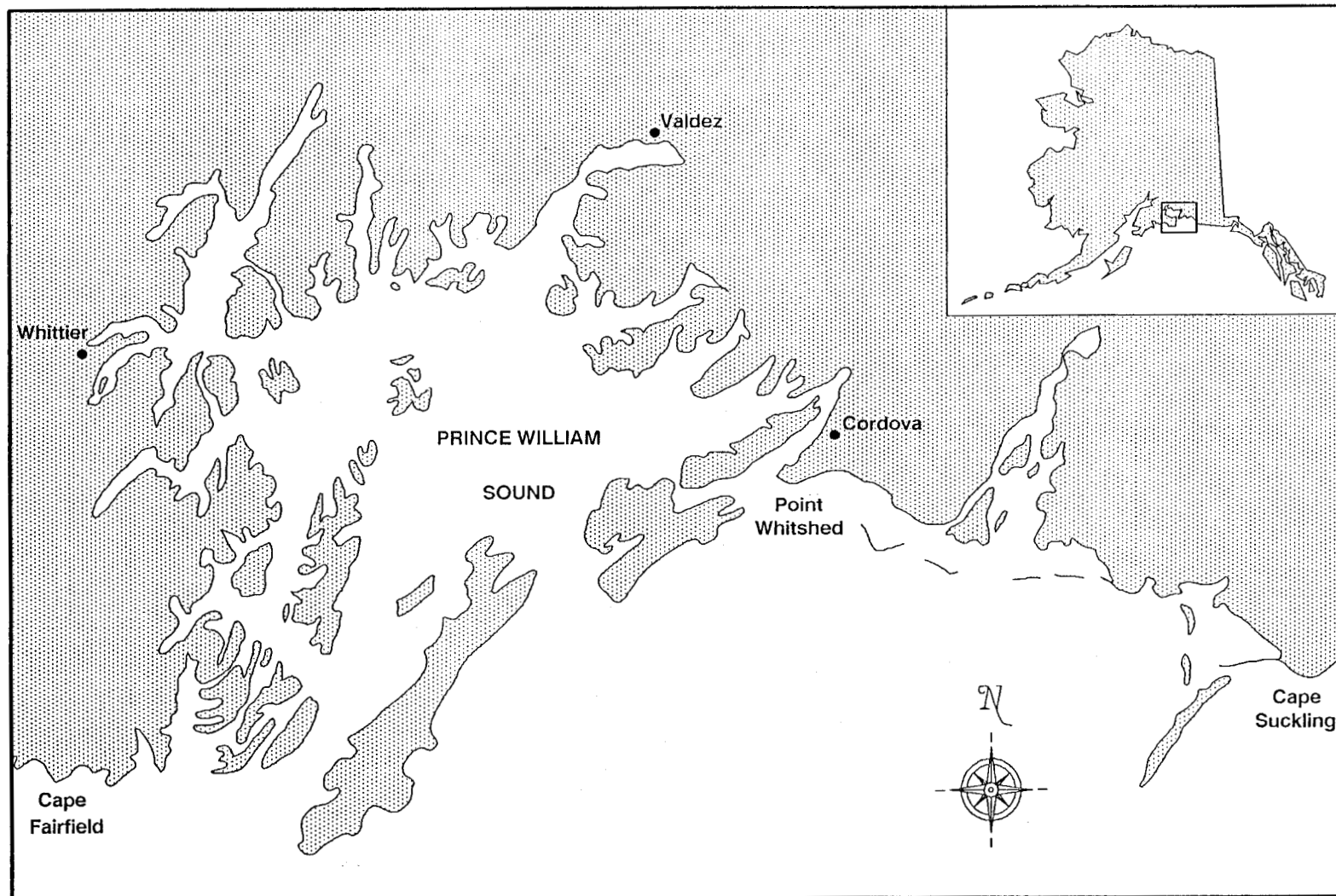


Figure 1. Map of Prince William Sound, Alaska.

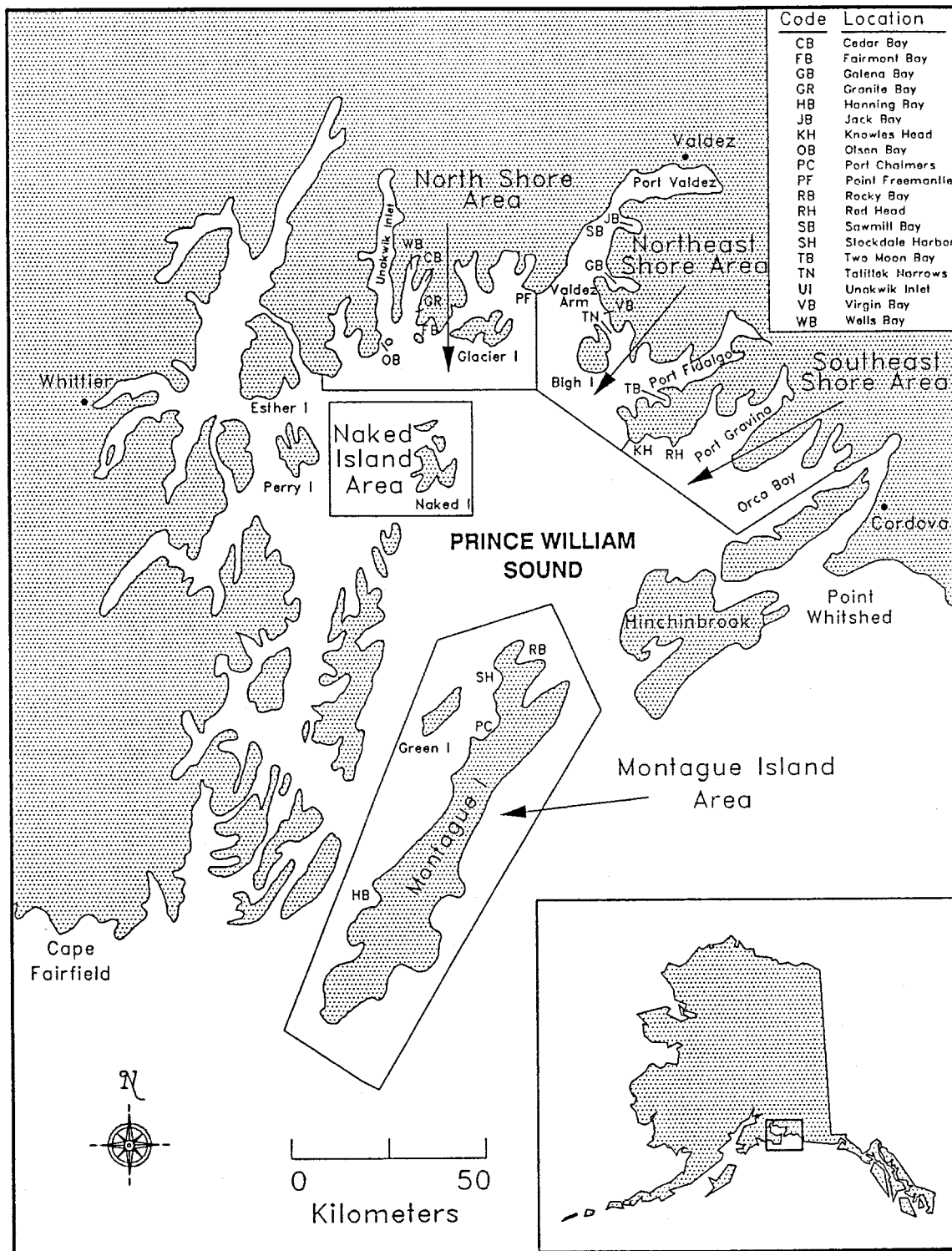


Figure 2. Location of the major spawning areas and commercial fisheries for Pacific herring in Prince William Sound, Alaska, 1988.

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